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COST EFFECTIVENESS STUDY OF WASTEWATER MANAGEMENT SYSTEMS FOR SELECTED U.S. COAST GUARD VESSELS

Volume IV - Development of Candidate Systems

Sidney Orbach

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1700 Broadway
New York, N.Y. 10019

February 1977

FINAL REPORT

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U.S. DEPARTMENT OF TRANSPORTATION

UNITED STATES COAST GUARD

... RESEARCH AND DEVELOPMENT

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16. Abstract

Eighteen system concepts for managing black (sewage and garbage grinder slurry) and gray (galley and turbid) wastewaters aboard six different U.S. Coast Guard Cutters are presented. Specific equipment configurations (number of units, model, capacities, etc.) necessary to synthesize each Wastewater Management System (WMS) concept on each vessel are given.

The 18 WMS concepts were synthesized as hybrids of five commercially available Marine Sanitary Devices (MSDs), namely, Jered, GATX, Chrysler, Grumman, and a CHT (Collection, Holding and Transfer) system. For purposes of hybridization, each MSD was analyzed in terms of two subsystems, namely, the waste collection/transport subsystem and the waste treatment/disposal subsystem. The 18 WMS concepts were selected on the basis of MSD subsystem combinations which were judged to have a good chance of succeeding without requiring extensive engineering changes, redesign, and elaborate testing. In MSDs whose treatment/disposal subsystem includes an incinerator in addition to other treatment equipment (Chrysler and Grumman), the substitution of a holding for the incinerator was also considered.

Each WMS concept was then analyzed as a function of the vessel to determine the equipment configuration required to synthesize that concept on the given vessel. This determination was made on the basis of the holding time requirements established in the vessel mission profile study (Volume VI), assumed waste generation rates and the crew size. If a given system concept could be synthesized by more than one equipment configuration, these were recorded as subchoices to be resolved on the basis of the merits of installation or further engineering considerations.

The WMS configurations for each vessel were developed without regard to installation considerations. A set of installation guidelines and assumptions were developed for use in determining the acceptability of each candidate system configuration on each vessel.

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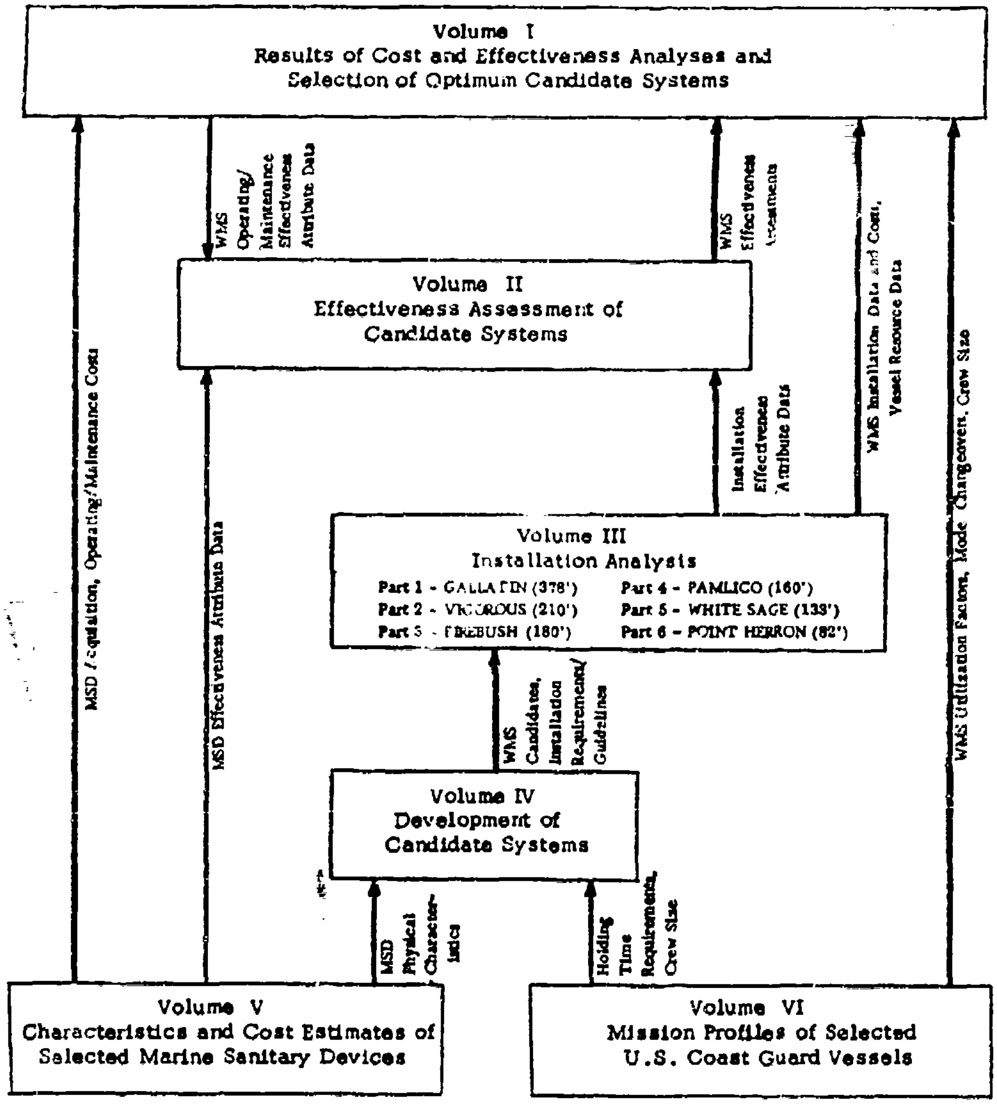
Mr. Scarano and Lt. Ed Magsig of the Office of Engineering, together with Mr. James A. White, of the Office of Research and Development provided valuable assistance in the formulation of the assumptions and guidelines governing the development of the candidate systems as well as the associated installation guidelines and assumptions.

PREFACE

The relationship among the volumes of the report is depicted below. This relationship does not convey all the information contained within each volume.



SUMMARY OF WASTEWATER MANAGEMENT SYSTEM CONCEPTS
(For Handling Shipboard Black and Gray Wastewaters)

WMS No.	TYPE: Coll/Trans Subsys (Black)	TYPE: Treatment/Disposal Subsystem: Black	TYPE: Treatment/Disposal Subsystem: Gray	ABBREVIATED NAME[1]
1	Gravity Collect.	Holding Tank	Holding Tank	GRV COL/B(HLT)/G(HLT)
2	Oil Recircul. (Chrysler)	Chrysler + Hld Tnk	Holding Tank	RECIRC/B(CHLR+HLT)/G(HLT)
3		Chrysler + Incin.	Holding Tank	RECIRC/B(CHLR+INC)/G(HLT)
4	Gravity Collect. (Grumman)	Grum Flow Thru+HldTk	Holding Tank	GRV COL/B(GRM+HLT)/G(HLT)
5		Grumman Flow Thru + Holding Tank		GRV COL//B+G(GRM+HLT)
6	Gravity Collect.	Holding Tank	Grum Flow Thru+ HldTnk	GRV COL/B(HLT)/G(GRM+HLT)
7	Gravity Collect. (Grumman)	Grum Flow Thru+Incin.	Holding Tank	GRV COL/B(GRM+INC)/G(HLT)
8		Grumman Flow Thru + Incinerator		GRV COL//B+G(GRM+INC)
9	Vacuum Collect. (Jered)	Holding Tank[2]	Holding Tank	VAC COL/B(HLT)/G(HLT)
10	↓	Incinerator	Holding Tank	VAC COL/B(INC)/G(HLT)
11	↓	GATX Evap.	Holding Tank	VAC COL/B(EVAP)/G(HLT)
12	↓	Holding Tank[3]	Grum Flow Thru+ Hld Tnk	VAC COL/B(HLT)/G(GRM+HLT)
13	↓	Incinerator	Grum Flow Thru + Incin.	VAC COL/G(GRM)/B+GS(INC)
14	M/T Pump Collect. (GATX)	Holding Tank	Holding Tank	PMP COL/B(HLT)/G(HLT)
15	↓	Incinerator	Holding Tank	PMP COL/B(INC)/G(HLT)
16	↓	GATX Evap.	Holding Tank	PMP COL/B(EVAP)/C(HLT)
17	↓	Holding Tank	Grum Flow Thru+Hld Tnk	PMP COL/B(HLT)/G(GRM+HLT)
18	↓	Incinerator	Grum Flow Thru + Incin.	PMP COL/G(GRM)/B+GS(INC)

(1) Used to identify system in output of computer program for quantifying effectiveness.

(2) Two subchoices available for WMS No. 9 as follows:

- 9a - Concentrated black water transferred from VCT to holding tank.
- 9b - Concentrated black water held in VCT.

(3) Two subchoices available for WMS No. 12 as follows:

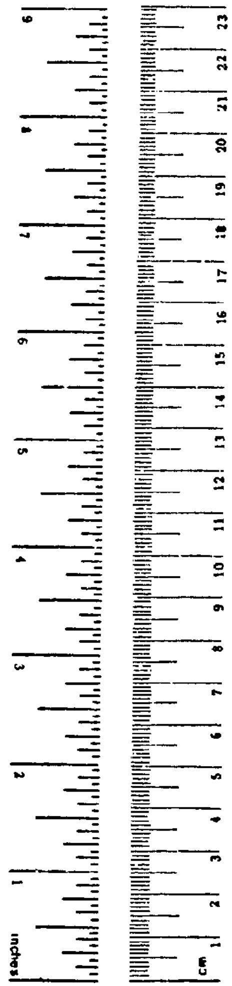
- 12a - Concentrated black water transferred from VCT to holding tank.
- 12b - Concentrated black water held in VCT.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

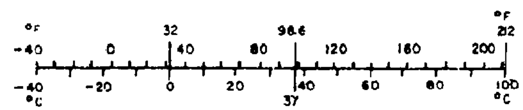
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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I. INTRODUCTION

A. WASTES TO BE MANAGED

This study is concerned with the management of black and gray wastewater on specified U.S. Coast Guard cutters while they are in restricted waters.

- Black water is defined as sanitary wastes emanating from commodes, urinals and garbage grinders.*
- Gray water is defined as:
  - .. Galley wastewater from sinks and kettles but excluding garbage grinder output.
  - .. Turbid water from lavatories, showers and laundry.
  - .. Drainage from air conditioners, drinking fountains and interior deck drains including deck drains in head spaces.
- Restricted waters are defined as inland lakes, streams, rivers, estuaries and coastal waters up to three miles from shore.

B. WASTEWATER MANAGEMENT SYSTEM CONSIDERATIONS

1. Four proprietary Marine Sanitary Devices (MSD), namely:

   - JERED vacuum collection/incineration
   - GATX pumped transfer/evaporation
   - Chrysler recirculating oil flush/incineration
   - Grumman flow-through/incineration

   and a fifth method, collection-holding-transfer system (CHT), provide the bases for the 18 Waste Management System (WMS) concepts. In this study, a WMS manages both black and gray water. This is often achieved by supplementing an MSD that previously handled black water only with gray water management. The Jered, GATX and Chrysler MSDs, in combination with a holding tank for gray water forms three of the 18 WMS concepts. The CHT concept was expanded to include tankage for gray water as well as black water management and constitutes another WMS concept. The Grumman MSD was originally designed to handle

* U.S. Coast Guard legal opinion considers garbage grinder output as sewage.

black and gray waters and constitutes a fifth WMS concept. The remaining 13 WMS concepts were synthesized by hybridizing the subsystems of the above MSDs and the CHT concept.

2. The hybridized WMS concepts were synthesized by:

   - Substitution of the JERED reduced flush/vacuum collection subsystem or the GATX reduced flush/pumped transfer collection subsystem for a standard volume flush/gravity drainage subsystem.
   - Substituting an incinerator for an evaporator and vice versa.
   - Substitution of a holding tank for an incinerator or evaporator.
   - Changing the type of wastewater and the point of entry in the Grumman flow-through system.

   Hybridization of subsystems was limited to combinations which are either known to work or are considered to have a good chance of working, i.e., no basic or major problems are anticipated. Combinations whose operation is in doubt were not considered.

   Management of black water is easier in the first two systems (Jered & GATX) by use of reduced flush commodes producing smaller volumes to be managed. The third system (Chrysler) reduces the volume still further by separating and recirculating the flushing medium (oil). The Grumman MSD prototype is the only flow-through system, i.e., it discharges treated effluent overboard.

3. Each of the 18 WMS concepts was analyzed in the context of meeting the requirements of each of the six vessels included in this study. MSD component scaling and use of multiple units were utilized in order to develop the 18 WMS concepts into WMS configurations which can accommodate the capacity requirements of each vessel.

   Proprietary equipment, proprietary processes and designs are used as is. Variations in size or capacity are permitted where

- equipment is a catalog item, available off-the-shelf, previously built and used, or
- manufacturer has a design for which he will provide physical characteristics, resource and interface requirements.

4. Design information pertaining to proprietary Waste Management Systems is as accurate as obtainable or is the best estimate by manufacturer or study team. Caution is advised in using the data herein for design. Manufacturers should be consulted for best recommendations in the use of their equipment.

5. As a general rule, redesign of equipment or processes is beyond the scope of this study. However, certain exceptions are allowed as detailed below.

   - Equipment Modification

     - .. The Grumman MSD prototype, developed for the Coast Guard, is modified by direction of the Coast Guard. The components deleted and components added are detailed in the text discussing the systems involved. The structural frame of the MSD remains unaltered and equipment of the original design remain fixed in their original location(s).

     - .. Proprietary tanks can be altered in the number, size and location of pipe connections.

   - Flow Modification: The Grumman MSD prototype, originally designed for mixed gray and black water (standard volume) is allowed to operate with

     - .. mixed gray and black water (standard volume)
     - .. black water only (standard flush volumes)
     - .. gray water only
     - .. gray water into main inlet and reduced volume black water going directly to the incinerator or sludge holding tank

Not having been tested, reduced volume black water is not allowed through the flow-through system because of questionable performance capability.

- Flow Equalization: Ordinary tanks which act as interfaces between subsystems or at either end of a system can be added, deleted or altered in size or shape. This does not apply to vacuum collection tanks (JERED), oil/sewage separating tanks (Chrysler) or evaporating tanks (GATX).

- Waste Distribution: Because of the effects of hybridizing the MSD subsystems:

  - .. interface pumps may be added, deleted, changed in type (e.g., macerating), altered in capacity and/or
  - .. multiple pumps may be used (e.g., to multiple evaporators) or
  - .. multiple diverting valves may be manifolded to transfer pumps (e.g., to multiple evaporators) whether single or dual installation

- Interface Controls: Because of the effects of hybridizing MSD subsystems, additional electrical, pneumatic or hydraulic control equipment may be required. For the purposes of this study, it is assumed that interface controls are available, do not have large weight and volume penalties and will not be defined. Therefore, no attempt will be made to estimate the costs of interface equipment or design efforts.

6. Figure 1 presents a matrix of the 18 synthesized WMS concepts as a function of collection method and disposal method. Further details of these 18 WMS concepts, in configurations potentially suitable as candidates for each vessel considered in this study, are presented in Section III.

- Management of shipboard black (sewage and garbage grinder output) and gray (galley and turbid) wastewater streams
- Separate drain lines for sewage, galley, and turbid wastewaters
- Garbage grinder output is considered sewage (black water) and is assumed to be operationally separable from galley wastewater
- Deck drains are connected to galley and turbid drain lines
- Galley and turbid drain lines are always gravity operated

Treatment Disposal (Bk & Gr.) / Sewage Collection	NO DISCHARGE: HOLDING TANKS	NO DISCHARGE: INCINERATOR	NO DISCHARGE: EVAPORATOR	NO DISCHARGE: OIL RECIRCULATION (Chrysler): With Hold Tank	NO DISCHARGE: OIL RECIRCULATION (Chrysler): With Incinerator	FLOW THROUGH (Grumman): WITH SLUDGE HOLDING TANK, CENTRIFUGE FEED: Black Only	FLOW THROUGH (Grumman): WITH SLUDGE HOLDING TANK, CENTRIFUGE FEED: Black & Gray	FLOW THROUGH (Grumman): WITH SLUDGE HOLDING TANK, CENTRIFUGE FEED: Gray Only	FLOW THROUGH (Grumman): WITH SLUDGE INCINERATOR (Thiokol), CENTRIFUGE FEED: Black Only	FLOW THROUGH (Grumman): WITH SLUDGE INCINERATOR (Thiokol), CENTRIFUGE FEED: Black & Gray	FLOW THROUGH (Grumman): WITH SLUDGE INCINERATOR (Thiokol), CENTRIFUGE FEED: Gray Only
GRAVITY DRAINAGE	BLACK Sewage and garbage grinder output to Holding Tank GRAY Galley/Turbid to separate Holding Tank 1			BLACK Chrysler oil recirculation system for sewage Settled sewage & garbage grinder output to Sludge Holding Tank GRAY Galley/Turbid to separate Holding Tank 2	BLACK Chrysler oil recirculation system for sewage Settled sewage and garbage grinder output to Incinerator (Chrysler) GRAY Galley/Turbid to Holding Tank 3	BLACK Sewage and garbage grinder output to Grumman via Influent surge tank Sludge to Holding Tank GRAY Galley/Turbid to separate Holding Tank 4	BLACK&GRAY Sewage, garbage grinder output, Galley/Turbid to Grumman via Influent surge tank Sludge to Holding Tank 5	BLACK Sewage and garbage grinder output to Holding Tank GRAY Galley/Turbid to Grumman via Influent surge tank Sludge to (either separate or sewage) Holding Tank 6	BLACK Sewage and garbage grinder output to Grumman via Influent surge tank Sludge to Incinerator (Thiokol) GRAY Galley/Turbid to Holding Tank 7	BLACK & GRAY Sewage, garbage grinder output, Galley/Turbid to Grumman via Influent surge tank Sludge to Incinerator (Thiokol) 8	
REDUCED VOLUME FLUSH COLLECTION VACUUM COLLECTION (JERED)	BLACK Vacuum collection of sewage in VCT Sewage transfer to Holding Tank or held in large VCT Garbage grinder output to VCT or directly to Holding Tank by gravity GRAY Galley/Turbid to separate Holding Tank 9	BLACK Vacuum collection of sewage in VCT Sewage and garbage grinder output to Incin. (Jered or Thiokol) GRAY Galley/Turbid to Holding Tank 10	BLACK Vacuum collection of sewage in VCT Sewage and garbage grinder output to GATX Evaporator GRAY Galley/Turbid to Holding Tank 11					BLACK Vacuum collection of sewage in VCT Sewage transfer to Holding Tank or held in large VCT Garbage grinder output to VCT or directly to Holding Tank by gravity GRAY Galley/Turbid to Grumman via influent surge tank Sludge to (separate & sewage) Holding Tank 12			BLACK Vacuum collection of sewage in VCT Sewage & garbage grinder output to Incin. (Thiokol) GRAY Galley/Turbid to Grumman via influent surge tank Sludge to Incin. (Thiokol) 13
MACERATOR/TRANSFER PUMP COLLECTION (GATX)	BLACK M/T Pump collection of sewage Sewage and garbage grinder output to Holding Tank GRAY Galley/Turbid to separate Holding Tank 14	BLACK M/T Pump collection of sewage Sewage and garbage grinder output to Incin. (Jered or Thiokol) GRAY Galley/Turbid to Holding Tank 15	BLACK M/T Pump collection of sewage Sewage and garbage grinder output to GATX Evaporator GRAY Galley/Turbid to Holding Tank 16					BLACK M/T Pump collection of sewage Sewage and garbage grinder output to Holding Tank GRAY Galley/Turbid to Grumman via influent surge tank Sludge to (separate or sewage) Holding Tank 17			BLACK M/T collection of sewage Sewage and garbage grinder output to Incin. (Thiokol) via surge tank GRAY Galley/Turbid to Grumman via influent surge tank Sludge to Incin. (Thiokol) 18

Figure 1

WMS CONCEPTS FOR SHIPBOARD BLACK AND GRAY WASTEWATERS

C. VESSEL CONSIDERATIONS

1. In order to realistically evaluate the 18 WMS, each WMS and its size and capacity variations are applied to six USCG cutters of differing dimensions and types, shown in Figure 2.

No.	Name	Class	Type	Length	Manning	Longest Holding Time Required (Hrs)
1.	Gallatin	WHEC	High Endurance Cutter	378'	152	97.5
2.	Vigorous	WMEC	Medium Endurance Cutter	210'	60	172.0
3.	Firebush	WLB	Buoy Tender	180'	50	277.9
4.	Pamlico (under constr.)	WLIC	Buoy Tender	160'	13	501.0 *
5.	White Sage	WLM	Buoy Tender	133'	21	65.5
6.	Point Herron	WPB	Patrol Boat	82'	8	99.0

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

Figure 2

VESSELS CONSIDERED

2. The longest number of hours a vessel is expected to stay continuously within restricted waters is taken from actual mission profile data**. This value, shown in Figure 2, is the basis for sizing holding tanks. For the purposes of this study, vessels are always assumed to pump (or drain) all wastes overboard in unrestricted waters. Previously collected and stored wastewaters are also discharged overboard. All or portions of the WMS that are not needed in unrestricted waters will be shut down. The same portions will also be shut down while the vessel is tied up at its own pier.

3. Design information pertaining to vessels is as accurate as obtainable or is the best estimate by the study team. Caution is made against using the data herein for design without verification.

** See Mission Profiles document for this study for types and details of sorties.

D. WASTE GENERATION RATES ASSUMED

Waste generation rates were assumed in lieu of actual data from the vessels under study or similar ones. The values in terms of gallons per capita per day (gpcd) are indicated in Figure 3.

Type/Source		gpcd	Derivation/Reference
Commodes and Urinals	Standard fixtures	9	Ships Waste Management Study, NSRDC/A Rept 28-999, Nov. 1973 average of officers and crew at sea (9.13 gpcd), weighted by numbers of officers and crew
	Chrysler	0.46	Bioastronautics Data Book NASA SP-3006 Urine value - 2nd edition Fecal value - 1st edition
	GATX and JERED	1.875	5 urinal flushes/day @ 1 pint/flush 2 commode flushes/day @ 3 pint/flush plus human waste (Chrysler value)
Galley		8	USCG. Polab Program Phase II presentation. Weighted waste generation rates for officers and crew from NSRDC/A Report cited above yields a value of 7.5 gpcd.
Turbid		22	Average of NSRDC/A Report and USCG presentation values (19.5 and 25, respectively)
Garbage Grinder		1.5	USCG presentation value
Sludge generation rate in Grumman WMS		1/12 of influent	Grumman: 5 gal/hr sludge from 60 gal/hr input

Figure 3

WASTE GENERATION RATES ASSUMED

E. DESIGN GUIDELINES

1. For simplicity, the flow diagrams do not show details of MSD's, nor do they show pumps, check valves and most other valves. The valves that are shown are for the purpose of clarifying ambiguous functions.

2. Black water is never put into a gray water holding tank but gray water is permitted in a black water tank at which time it is considered black water. The latter situation is common for off-loading.

3. In sizing of tanks for collecting and/or holding and/or transfer, additional volume is included equal to 20% of the maximum liquid volume to allow for sloshing and/or safety in filling. In vacuum collection tanks, this volume also allows for air to separate from the influent liquid. All values given in this report for tank volumes include the extra 20%.

4. Sewage holding tanks must be aerated at a rate of 16.3 SCFM per 1000 gallons of liquid. Gray water tanks are not aerated. Compressed air for aerating a holding tank or atomizing sewage in an incinerator is assumed available from ship's low pressure air supply, if such a supply exists. If no compressor is available on board the vessel, it is assumed that one will be installed as part of the WMS installation. The air supply requirements for tank aeration is based on the following considerations:

   - The aeration rate
   - The maximum tank capacity
   - The back pressure, which is a function of the liquid level in the tank.

   Design of the air supply is based on aeration requirements for a full tank. It is noted that when the tank is not full, the back pressure is reduced, resulting in a greater flow of air. This must be considered in sizing the tank vent line.

5. A summary of installation requirements for the 18 WMS concepts is given in Figure 4.

WMS No.	FIXTURES: Commodes	FIXTURES: Urinals	FIXTURES: Urinal Valves	FIXTURES: Sewer Lines	Flush Medium	Holding Tank	Vent Line(s)* from	Incinerator Stack	VESSEL RESOURCES REQUIRED: Fuel Oil	VESSEL RESOURCES REQUIRED: Electricity	VESSEL RESOURCES REQUIRED: Compressed Air to	VESSEL RESOURCES REQUIRED: Excess Ambient Air for	VESSEL RESOURCES REQUIRED: Cooling Water
1	Standard (Existing)	Standard (Existing)	Standard (Existing)	Standard Gravity Drains (Existing)	Sea Water	B & G	BHT	No	No	Centralized	BHT		No
2					Recirc. Oil	S & G	MSD & SHT	No	No		SHT		No
3					Recirc. Oil	G	MSD	Yes	Yes		Incinerator	Incinerator	No
4					Sea Water	S & G	A/SHT/O_3	No	No		A & SHT		Yes
5						S	A/SHT/O_3	No	No		A & SHT		Yes
6						B & S	BHT & O_3	No	No		BHT		Yes
7						G	A & O_3	Yes	Yes		A & Incin.	Incinerator	Yes
8						-	A & O_3	Yes	Yes		A & Incin.	Incinerator	Yes
9	Special Vacuum Operated (Jered)		Standard (Existing) Valves Plus Urinal Discharge Valves	Vacuum Sewer 1-1/2 & 2" lines	Fresh Water	B & G	VCT & BHT	No	No		BHT		No
10						G	VCT	Yes	Yes		Incinerator	Incinerator	No
11						G	VCT & CO	No	No		CO		No
12						B & S	VCT/BHT/O_3	No	No		BHT		Yes
13						-	VCT & O_3	Yes	Yes		Incinerator	Incinerator	Yes
14	Special Operated with M/T Pump (GATX)		Push Button Operated Solenoid Valve	Pressure Sewer 1-1/4" Line		B & G	BHT	No	No	Dispersed (Electrical) Connection to Every Commode, Urinal and M/T pump	BHT		No
15						G	A	Yes	Yes		A & Incin.	Incinerator	No
16						G	A & CO	No	No		A & CO		No
17						B & S	BHT & O_3	No	No		BHT		Yes
18						-	A & O_3	Yes	Yes		A & Incin.	Incinerator	Yes

* To weather deck
A = Surge Tank
B = Black Water
C = Grey Water
S = Sludge

CO = Catalytic Oxidizer
O_3 = Ozone Reactor
Incin. = Incinerator

BHT = Black water holding tank
GHT = Gray water holding tank
SHT = Sludge holding tank
VCT = Vacuum collection tank
MSD = Marine sanitary device

Figure 4

SUMMARY OF WMS INSTALLATION REQUIREMENTS

II. GUIDELINES AND CRITERIA FOR WMS INSTALLATION

A. WMS ACCEPTABILITY CRITERIA

1. Acceptability of candidate WMS configurations for installation on board a vessel shall be based on the following considerations:

   - All specified sized and required number of duplicate WMS equipment, except for holding tanks, must be accommodated, based on the established vessel space utilization guidelines.

   - Inability to accommodate the required black and/or gray water holding tank size, based on the vessel space availability guidelines below, shall not be deemed sufficient reason for rejecting a candidate WMS configuration. The maximum black and/or gray water holding tank size which can be accommodated shall be specified, using the guidelines for black/gray water holding capacity apportionment (Para. D1) and the minimum gray water holding tank requirements (Para. D3).

2. Using multiples of equipment or subsystems to meet the capacity requirements of each vessel in the study constitutes WMS configuration options within the WMS concept and does not yield a new WMS. Only one option will be chosen, based on installation factors, for subsequent analysis and evaluation.

B. VESSEL SPACE AVAILABILITY FOR WMS INSTALLATION

1. Vessel space utilization guidelines for WMS installation shall be as follows:

   - Fuel oil storage tank spa[illegible] all not be considered

   - Storeroom space may be considered

   - Washrooms and storeroom spaces may be considered if substitute locations for such can be designated

- Small components may be considered for relocation
- Incinerators shall not be located on the weather deck (even if an enclosure is provided).
- All WMS stacks should be located within the existing ship's stack housing (Fiddley), if possible.

2. For ease of installing WMS, components may be separated, if feasible. However, decentralization o" equipment may require additional piping runs and more elaborate hook-ups.

3. Each vessel considered in this study is assumed to have one or two holding tanks with discharge pumps for off-loading overboard or to pier connections on either side of the vessel. Vessel plans on hand show holding tanks and the study assumes that installations will be complete by the end of the study. The fact that one or more holding tanks exist on a vessel is not taken to be a constraint on:

   - Location of a new or replacement tank, or other WMS equipment.
   - Sizing of a new or replacement tank.
   - The type of waste an existing tank will receive.

4. Where shipboard configurations do not agree with ship compartment and equipment layout drawings provided by USCG, the shipboard configurations shall govern (for the Pt. Herron, a holding tank is to be installed).

C. <u>VESSEL DRAIN SYSTEMS</u>

1. Piping configurations shall be assumed to agree with appropriate piping drawings supplied by the Coast Guard and estimated piping costs shall be based upon such configurations.

2. For those WMS configurations involving vacuum or pump transfer waste collection (which require special drain piping), existing drain piping will not be used but shall be left in place, if it does not interfere with new installations.

3. Sewer networks for different types of wastes will remain independent until reaching the centralized collection, disposal or treatment device(s). They join in the device or in an adjacent manifold. The manifolds for black and gray water never join.

   Collected gray water is always brought to a central point in a single drainage system regardless of subsequent disposition. A large vessel may have two drainage systems, one forward and one aft, in which case, there are two central points. Only the gray water drainage system(s) is permitted to have an overboard bypass line. A gravity flow bypass is physically possible only where the central manifold is sufficiently high for sloped drain lines to reach a port and/or starboard scupper. Note that when the vessel is hooked up to a pier connection, gray water may not be discharged overboard and provisions must be made for pumping the gray water into the pier connection.

4. Pier sewers for off-loading wastewater are non-pressurized, gravity drained and will accept no more than 30 gpm. Present minimum size of pier connection and pipe riser is four inches. Where small volumes of wastewater are to remain isolated and yet to be off-loaded to the pier sewer, much smaller pipe risers will be assumed acceptable. Precautions against pipe clogging must be taken or be inherent in the WMS.

5. Garbage grinders may be found in either the galley, scullery or in both of these locations. They will remain in current locations. Where no grinder exists, it is assumed that one will be installed in the galley. The drain line from the grinder remains separate from other gravity flow sewer lines until it reaches a holding tank or treatment equipment. With vacuum or pumped sewers, exceptions may be made (see Section III for the particular systems involved).

D. CHT INSTALLATION

1. The following considerations shall apply to black/gray water holding tanks:

   - Where limited holding tank capacity exists, black water storage capacity shall have priority. Remaining storage capacity shall be used for gray (see minimum gray water holding tank requirements).
   - No more than three (3) holding tanks shall be located on any one vessel.
   - Where no incinerators are provided, avoid using the VCT (vacuum collection tank) as the holding tank (because it is difficult to aerate). Where feasible, provide a tank to accomplish the holding function. A VCT shall be used primarily for collection.
   - No provision shall be made for black water diversion into a gray water holding tank.
   - No provision shall be made for diversion of black water overboard upstream of the centralized collection, disposal or treatment device(s).

2. Holding tank design specifications shall include:

   - Aeration of tank - black water only (see discussion on vent requirements in Section I).

- Sloped bottom, if possible.
- Discharge pump suction at bottom of tank, if possible.
- Tank structural support, if required, shall be provided on the outside of the tank.

3. A minimum gray water handling capability must be provided for each vessel. In a system where gray water is dumped as and when received, and the manifold is below the waterline, an overboard discharge pump is required with a feed tank holding enough liquid for 20-25 minutes of pump operation. The pump is nominally rated at 20% more than four times the daily average flow of wastewater in order to accommodate peak flows. If the manifold is above the waterline, neither pump nor feed tank is required since overboard discharge can be achieved by gravity.

   If the manifold is above the waterline, a feed tank and an overboard discharge pump may still be required in order to transfer the gray water to the pier connection. However, away from the pier, a gravity bypass will allow overboard discharge without power.

   The gray water feed tank and overboard discharge pump can be eliminated where the central gray water manifold which is above the waterline can drain by gravity into a vented black water tank (not a vacuum collection tank). Such a collection subsystem can drain overboard by gravity while away from the pier and to the black water tank for pumped transfer to the pier connection.

   In this situation the discharge pump for the black water tank may have to be resized to handle peak flows of black and gray water combined. This situation is permitted only if the black water tank can hold sufficient water for 20-25 minutes of pumping. If this condition cannot be met then a minimum gray water feed tank and discharge pump must be provided.

E. INSTALLATION ASSUMPTIONS, STANDARDS AND PRACTICES

1. Crew sizes shall be those stated in the USCG solication (see Figure 2).

2. Where the WMS requirements for compressed air would overload the vessel supply system, an allowance is to be made to replace the vessel's compressor with a larger unit while retaining the accumulator, if possible.

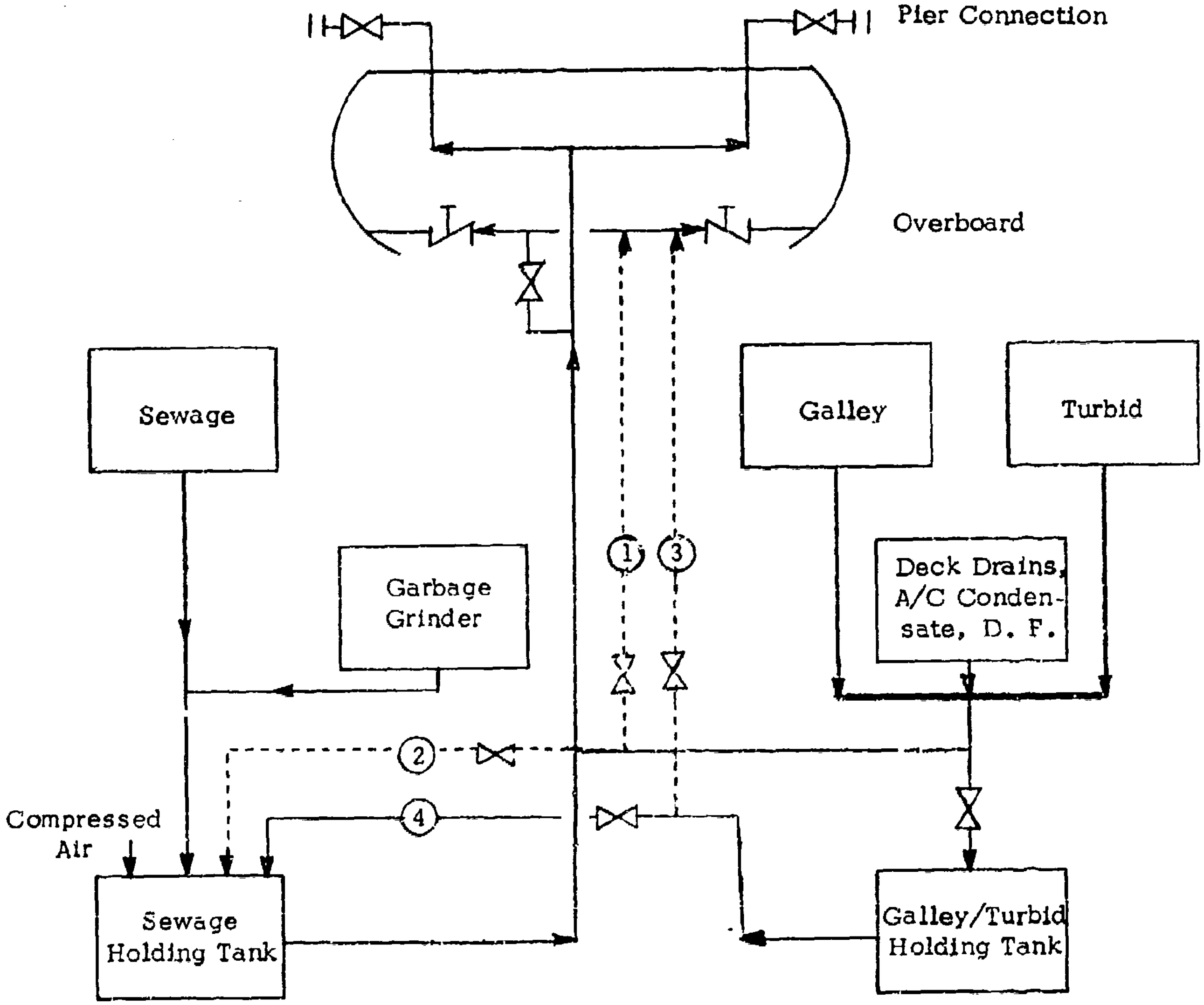
3. U.S. Public Health Standards (Handbook on Sanitation of Vessel Construction - HEW Public Health Service Publication No. 393) shall apply.

4. All USCG published rules and regulations shall be applicable.

5. Standard, acceptable, architectural practices shall be used in cost estimating. Standard shipyard labor rates shall be used in cost analysis, regardless of shipyard location.

III. WASTE MANAGEMENT SYSTEMS DEFINITIONS, OPTIONS AND INSTALLATION CHARACTERISTICS

1. Full Volume Flush Gravity Collection/Holding Tank for Black Water/ Holding Tank for Gray Water



1. Urinals and commodes are the existing standard fixtures, supplied by the existing flush water (sea water) supply system. Drain lines are standard sized, sloped sewers.

2. For this system, two vented holding tanks are required: one for sanitary wastes and ground garbage and one for galley and turbid (G/T) wastes. The drainage system is to be designed so that sanitary wastes cannot drain into the G/T holding tank. Drain lines for galley and turbid wastes remain separate until reaching the holding tank.

3. The maximum volumes required for these tanks to hold all wastes generated during the longest stay in restricted waters, according to recorded mission profile data, is given in Table 1. The volumes include an additional 20% of the maximum liquid volume as safety margin.

Table 1

MAXIMUM HOLDING TANK VOLUMES

Vessel	Man-ning	Longest Holding Time Required (Hrs)	Sanitary				Galley and Turbid		
			gal	cu ft	Compressed Air SCFM	Discharge Pump gpm	gal	cu ft	Discharge Pump gpm
Gallatin (378')	152	97.5	7,781	1,040	106	30	22,230	2,972	30
Vigorous (210')	60	172.0	5,418	724	74	30	15,480	2,069	30
Firebush (180')	50	277.9	7,295	975	99	30	20,843	2,786	30
White Sage(133')	21	65.5	722	97	9.8	10-30	2,063	276	30
Pamlico (160') (Under Constr.	[illegible]	501.0*	3,419	457	46	30	9,770	1,306	30
Point Herron(82')	8	99.0	416	56	5.7	10-17	1,188	159	17

*Based on data from USCG's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

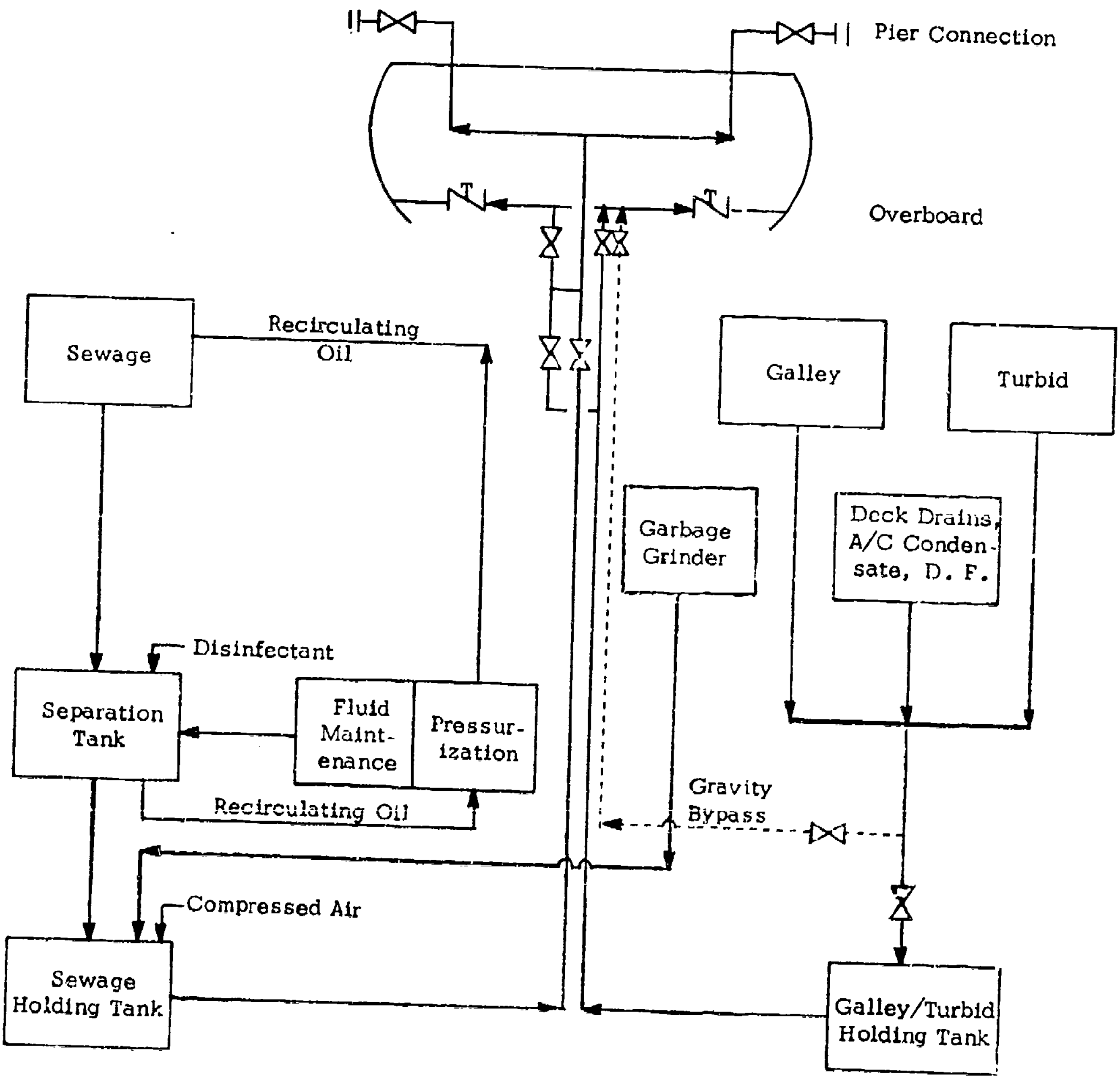
4. The sanitary holding tank is aerated to prevent septic, odor generating conditions. Compressed air can be supplied by the vessel's low pressure system or by a separate compressor. The compressed air flow rates given in Table 1 for the maximum volume tank are based on 16.3 SCFM per 1000 gal. of liquid. Pressure should nominally be 23 ft. water column greater than the maximum depth of the holding tank. If tank size is less than maximum air flow rate is reduced proportionately.

5. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. Provision is made to bypass the G/T holding tank during such times. The sanitary tank cannot be bypassed. If the G/T drain manifold is above the water line, the bypass line would be installed to drain directly overboard. This shows on the diagram as line (1). If vessel configuration will not permit line 1 to drain by gravity, then line (2), leading to the sanitary tank, is the next choice. This line will permit discharge of G/T wastes along with sanitary wastes to overboard in unrestricted waters and to the pier connection while tied up.

6. In those cases where the G/T holding tank size does not match the sanitary holding tank size in hours, and lines 1 or 2 are not installed since they cannot drain by gravity, then line 3 is chosen to conduct pumped G/T wastes to overboard. This line would be used while the vessel is in restricted waters (sanitary wastes must be held) and the G/T holding tank is full. Line 4 is installed to transfer the contents of the G/T holding tank to the sanitary tank during pier side pump out.

7. Each holding tank will have a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inches. Pumps for the sanitary tanks on the White Sage and Point Herron could be as small as 10 gpm and still provide an evacuation time of one hour or less. However, these pumps should have a capacity as great as the G/T tank pumps (30 and 17 gpm, respectively). If the G/T tanks are sized at less than the capacity goals given in Table 1, then both pump flow rates can be reduced to provide a nominal one hour pump out. The sanitary tank pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

2. <u>Full Volume Flush Oil Recirculation and Gravity Collection/Chrysler System with Sludge Holding Tank for Sewage/Holding Tank for Gray Water</u>



1. This recirculating flush system uses an immiscible oil for transport of sanitary wastes. Urinals and commodes are standard flushometer operated, gravity drain types that are flushed with a mineral oil. Flush fluid is separated from the sanitary wastes and returned for reuse by one or more of the Chrysler-built transport systems.

2. The Chrysler transport system separates sanitary wastes from the flush fluid and directs the wastes to the sanitary holding tank. The recirculated oil is pressurized for redistribution. An oil accumulator provides for periodic flow surges. A bleed stream from the accumulator continuously flows through purification units and returns to the reservoir in the separation tank. In smaller systems, the pressurization pumps, accumulator and purification (fluid maintenance) components are mounted on a single pallet. In large systems (160 men), all three are individually mounted.

3. The transport system is available in three capacities for the range of crew sizes on Coast Guard vessels:

   - Model A - 20 men
   - Model A/B - 50 men
   - Model B - 160 men

   Options for the larger models are multiples of smaller models as shown in Table 2. All optional systems have design capacities equal or greater than required except for the 50 man Option II. Since this selection is somewhat underrated, it will require more frequent replacement of oil purification expendables and will probably be subject to periods of slightly dirty flush fluid. Disadvantages of multiple components/systems are increased acquisition cost, complexity of the overall system, possibility of component failures, operating and maintenance man-hours and need for increased repair parts availability. Advantages to multiple installations are fewer

Table 2

COMPONENT OPTIONS

Crew Size		8	13	21	50		60			152	
Option					I	II	I	II	III	I	II
Separator Tank	Model A	1	1	1		2		1	3		
	Model A/B				1		1	1			3
	Model B									1	
Pump & Fluid Maint.	Model A	1	1	1	1	2	1	2	3		3
Pump Package	Model B									1	
Fluid Maint. Module	Model B									1	
Oil Accumulator										1	

restrictions on component location, components can be closer to head spaces resulting in smaller and shorter pipe runs, better weight distribution, lighter foundation framing, redundancy of systems/components.

4. Physical characteristics of the transport system components are given in Table 3. The oil accumulator, which is not supplied with the Chrysler Model B, should have a total volume of 46.8 cu. ft. The volume, which is sized proportionately to the large accumulator of Model A, can be provided in one or more upright cylinders. The contained oil will weigh about 1500 lbs.

5. Resource requirements for the oil transport system are given in Table 4. Pipe connection sizes are given in Table 5.

6. A sanitary holding tank receives the sewage (sludge) that settles out of the transport oil in the separation tank. The sludge is pumped from the tank in 10 second bursts of 2 to 6 gallons, depending upon pipe resistance. The holding tank also receives garbage grinder wastes. The ground garbage flows through an unpressurized, gravity drain pipe. The maximum volumes required for the tank to hold all of these wastes generated during the longest stay in restricted waters, according to mission profile data, is given in Table 6.

Table 3

COMPONENT PHYSICAL CHARACTERISTICS

Oil Transport System Components	Capacity	Weight (lbs)		Volume (cu ft)	Dimensions (inches)		
		Dry	Filled		Height	Length	Width
Chrysler Model A	20 men						
Separation Tank *		635	1370	51.9	68	55	24
Pressurization and Fluid Maintenance Pkg.		435	540	59.6	67	48	32
Chrysler Model A/B	50 men						
Separation Tank *		1000	2400	79.1	68	67	30
Pressurization and Fluid Maintenance Pkg.		435	540	59.6	67	48	32
Chrysler Model B	160 men						
Separation Tank *		1060	3120	116.7	77	77	34
Fluid Maint. Pkg.		325	555	22.0	49	31	25
Pump Pkg.		245	250	10.6	18	34	30
Oil Accumulator(s)			△ 1500	46.8			

NOTE: Control panel is decentralized on current production models. Individual controls are located on separation tank and pump or pump and fluid maintenance package

* Separation tank normally has two vertical compartments which can be furnished as two individual tanks. This may help placement in tight quarters.

△ Weight of oil only.

Table 4

OIL TRANSPORT COMPONENT RESOURCE REQUIREMENTS

Oil Transport System Component	HP	Watts	Volts	Phase	Hertz	Ambient Air CFM	Remarks
Separation Tank (A, A/B, B)							
Macerator Pump Motor:	1-1/2		230	1	60		10 sec on, 2 min. off until level sensor in tank is satisfied.
		Optional	208	3	60		
			230	3	60		
			460	3	60		
Blower Motor (Separation Tank)	1/16		115	1	60	150	Continuous
Controls		250 max					
Pump & Fluid Maint. Sys. (A, A/B)							
Fluid Pump (2)	2		115/230	1	60		One pump operates continuously - manual switchover
		Optional	208	3	60		
			230	3	60		
			460	3	60		
Flush Fluid Pump Pkg. (B)							
Fluid Pump (2)	2		230	1	60		One pump operates continuously - manual switchover
		Optional	208	3	60		
			230	3	60		
			460	3	60		

Table 5

OIL TRANSPORT COMPONENT PIPE CONNECTIONS

Separation Tank (for Models A, A/B, B)	
Waste Inlet	4 in. NPT
Waste Outlet (Pump discharge)	1 in. NPT
Flush Fluid Outlet	1 1/2 in. NPT
Flush Fluid Return	1/2 in. NPT
Vent Blower Outlet	2 in.
Pump and Fluid Maintenance System (for Models A, A/B)	
Flush Fluid Inlet	1 1/2 in. NPT
Flush Fluid Supply	1 1/2 in. NPT
Bypass Fluid Return	1/2 in. NPT
Flush Fluid Pump Package (for Model B)	
Flush Fluid Inlet	1 1/2 in. NPT
Flush Fluid Supply	1 1/4 in. NPT
Fluid Maintenance Module (for Model B)	
Fluid Inlet	3/4 in. NPT
Bypass Fluid Return	1/2 in. NPT

Table 6

MAXIMUM HOLDING TANK VOLUMES

Vessel	Manning	Longest Holding Time Required (Hrs)	Sanitary gal	Sanitary cu ft	Sanitary Compressed Air SCFM	Sanitary Discharge Pump gpm	Galley and Turbid gal	Galley and Turbid cu ft	Galley and Turbid Discharge Pump gpm
Gallatin (378')	152	97.5	1,452	194	20	20	22,230	2,972	30
Vigorous (210')	60	172.0	1,011	135	14	14	15,480	2,069	30
Firebush (180')	50	277.9	1,362	182	18	19	20,843	2,786	30
White Sage(133')	21	65.5	135	18	1.8	10	2,063	276	30
Pamlico (160') (Under Constr.	13	501.0*	638	85	8.7	10	9,770	1,306	30
Point Herron(82')	8	99.0	78	10	1.1	10	1,188	159	17

* Based on data from USCG's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements

The volumes include an additional 20% of the maximum liquid volume as safety margin.

7. The sanitary holding tank is aerated to prevent septic, odor generating conditions. Compressed air is supplied at the flow rates given in Table 6 for the maximum volume tank, based on 16.3 SCFM per 1000 gal of liquid. Pressure should nominally be 23 ft. water column greater than the the maximum depth of the holding tank. If tank size is less than maximum, air flow rate is reduced proportionately.

8. A separate holding tank receives galley and turbid wastewater from drain lines that remain divided until reaching the holding tank. The maximum tank volumes required to hold all G/T water generated during the longest stay in restricted waters, according to recorded mission profile data is also given in Table 6. They include additional volume equal to 20% of maximum liquid volume as safety margin.

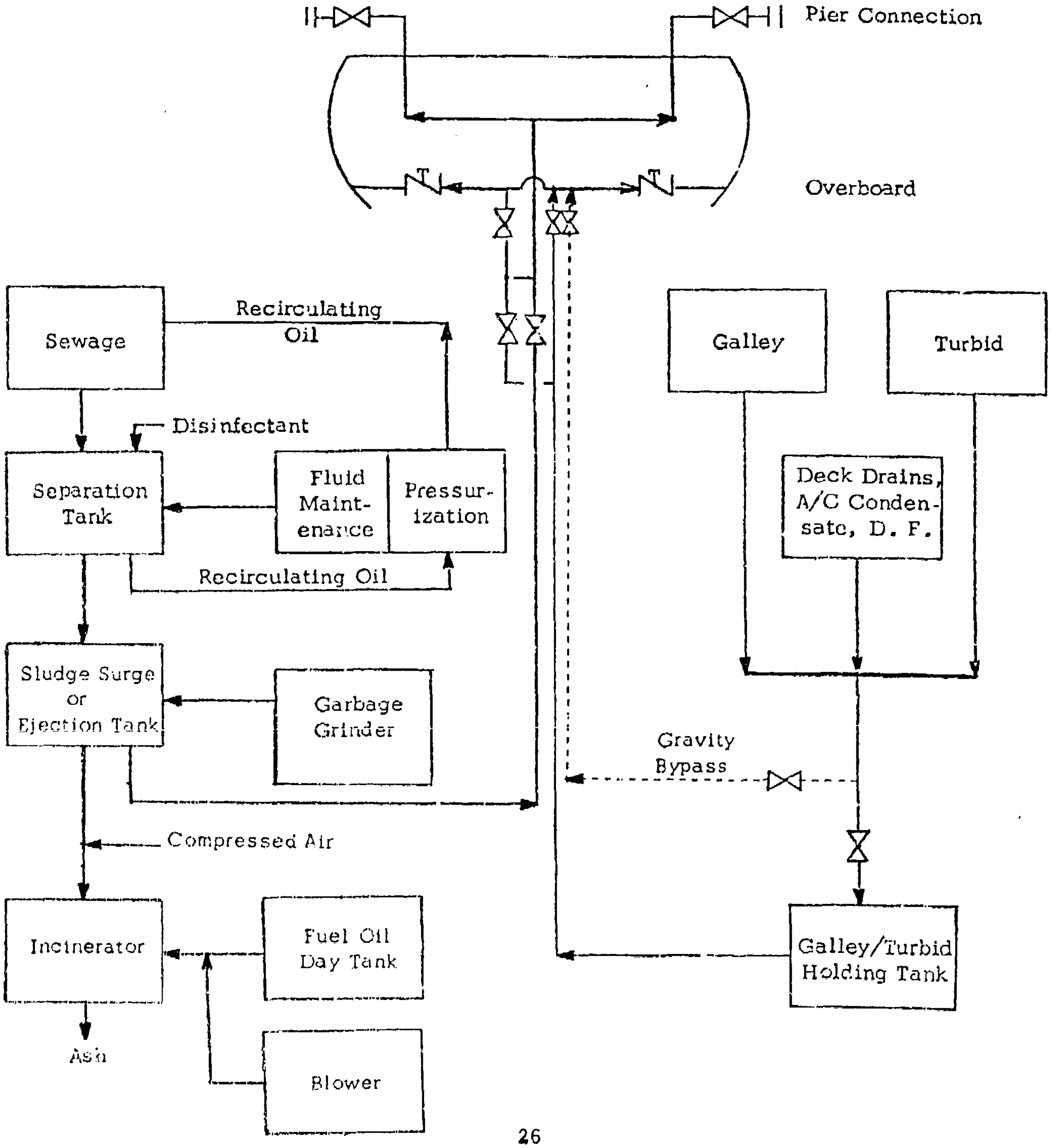
9. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. If the G/T drain manifold is above the waterline, provision can be made to bypass the holding tank. (The sanitary tank cannot be bypassed.) In those cases where the G/T holding tank capacity is less than that of the sanitary holding tank in terms of hours, the G/T wastes can drain overboard in restricted waters when the tank is full. If the vessel configuration will not allow gravity drainage overboard, G/T

wastes drain to the holding tank from which it can be pumped overboard.

10. When the vessel is tied up, sanitary and G/T wastes are pumped to a pier connection. Since the sanitary holding tank is small relative to the G/T holding tank, each tank has its own riser to the pier connection manifold. Valving permits isolation of lines and independent discharge.

11. Each holding tank will have a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inch. Nominal pump out time for each tank should be one hour if the resulting flow rate falls between these limits. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

3. Full Volume Flush Oil Recirculation and Gravity Collection/Chrysler System with Incinerator for Sewage/Holding Tank for Gray Water



1. This recirculating flush system uses an immiscible oil for transport of sanitary wastes. Urinals and commodes are standard flushometer operated, gravity drain types that are flushed with a mineral oil. Flush fluid is separated from the sanitary wastes and returned for reuse by one or more of the Chrysler-built transport systems.

2. The Chrysler transport system separates sanitary wastes from the flush fluid and directs the wastes to the incinerator. The recirculated oil is pressurized for redistribution. An oil accumulator provides for periodic flow surges. A bleed stream from the accumulator continuously flows through purification units and returns to the reservoir in the separation tank. In smaller systems, the pressurization pumps, accumulator and purification (fluid maintenance) components are mounted on a single pallet. In large systems (160 men) - all three are individually mounted.

3. The transport system is available in three capacities for the range of crew sizes on Coast Guard vessels:

   - Model A - 20 men
   - Model A/B - 50 men
   - Model B - 160 men

   Options for the larger models are multiples of smaller models as shown in Table 7. All optional systems have design capacities equal or greater than required except for the 50-man Option II. Since this selection is somewhat underrated, it will require more frequent replacement of oil purification expendables and probably be subject to periods of slightly dirty flush fluid.

4. The sewage sludge and ground garbage slurry collected on the White Sage, Point Herron and the Pamlico will be adequately burned in a Model A incinerator. A Model C incinerator is required for the Vigorous and Firebush and two C Models for the Gallatin in order to keep daily burn times under 19 hours. Sludge holding tanks are needed

on the three larger vessels to equalize the flow to the incinerators. These tanks should be located close to and on the same deck as the separation tanks.

5. When a vessel is at its pier in home port or is beyond restricted zones for a length of time, the recirculating flush system will continue to operate but without the incinerator. In order to pump overboard or to the pier connection, a sludge ejection tank is required as feed tank for the discharge pump. Ejection tanks are used on the three smaller vessels, but the three larger vessels utilize sludge holding tanks which feed the incinerator to serve the same purpose. The sizes of the sludge ejection tanks, based upon once a day pump out plus 20% for safety margin, are 20, 30 and 50 gal for the Point Herron, Pamlico and White Sage, respectively.

Table 7

COMPONENT OPTIONS

Crew Size		8	13	21	50		60			152	
Option					I	II	I	II	III	I	II
Separator Tank	Model A	1	1	1		2		1	3		
	Model A/B				1		1	1			3
	Model B									1	
Pump & Fluid Maint.	Model A	1	1	1	1	2	1	2	3		3
Pump Package	Model B									1	
Fluid Maint. Module	Model B									1	
Oil Accumulator										1	
Incinerator	Model A	1	1	1							
Incinerator	Model C				1	1	1	1	1	2	2
Sludge Holding Tank	Model B				1	1	1	1	1		
Sludge Holding Tank	Model C									1	1
Sludge Ejection Tank		1	1	1							

6. Disadvantages of multiple componnts/systems are increased acquisition cost, complexity of the overall system, possibility of component failures, operating and maintenance man-hours and need for increased repair parts availability. Advantages to multiple installations are simpler restrictions for locating components, components can be closer to head spaces resulting in smaller and shorter pipe runs, better weight distribution, lighter foundation framing, redundancy of systems/components.

7. Physical characteristics of the transport system components are given in Table 8. The oil accumulator, not supplied with the Chrysler Model B, should have a total volume of 46.8 cu ft. This volume which is sized proportionately to the large accumulator of Model A, can be provided in one or more upright cylinders. The contained oil will weigh about 1,500 lbs. Resource requirements for Chrysler WMS components are given in Table 9. Pipe connection sizes are given in Table 10 for standard, production components.

8. A gray water holding tank receives galley and turbid wastewater from drain lines that remain separate until reaching the holding tank. The maximum tank volumes required to hold all gray water generated during the longest stay in restricted waters, according to recorded mission profile data is given in Table 11. They include additional volume equal to 20% of maximum liquid volume as safety margin.

9. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. If the G/T drain manifold is above the waterline, provision can be made to bypass the holding tank. In those cases where the G/T holding tank capacity is inadequate, the G/T wastes can drain overboard in restricted waters when the tank is full. If the vessel configuration will not allow gravity drainage overboard, G/T wastes drain to the holding tank from which it can be pumped overboard.

10. When the vessel is tied up, sanitary and G/T wastes are pumped to a pier connection. Since the sludge surge or ejection tank is small relative to the G/T holding tank, each tank has its own riser to the pier connection manifold. Valving permits isolation of lines and independent discharge.

11. Each holding tank will have a discharge pump plus a back up pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inch. Nominal pump out time for each tank should be one hour if the resulting flow rate falls between these limits. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

Table 8

COMPONENT PHYSICAL CHARACTERISTICS

Components	Capacity	Weight (lbs)		Volume (cu ft)	Dimensions (inches)		
		Dry	Filled		Height	Length	Width
Chrysler Model A	20 men						
Separation Tank *		635	1370	51.9	68	55	24
Pump and Fluid Maintenance Pkg.		435	540	59.6	67	48	32
Incinerator		575	588	27.1	47	36.5	27.3
Chrysler Model A/B	50 men						
Separation Tank *		1000	2400	79.1	68	67	30
Pump and Fluid Maintenance Pkg.		435	540	59.6	67	48	32
Incinerator		575	588	27.1	47	36.5	27.3
Chrysler Model B	160 men						
Separation Tank *		1060	3120	116.7	77	77	34
Fluid Maint. Pkg.		325	555	22.0	49	31	25
Pump Pkg.		245	250	10.6	18	34	30
Sludge Holding Tank		610	1445	40.8	49	40	36
Incinerator		575	588	27.1	47	36.5	37.3
Chrysler Model C	-						
Sludge Holding Tank		980	2650	75.6	80	43	38
Incinerator		1600	1626	79.2	41	63	53

NOTE: Control panel is decentralized on current production models. Individual controls are located on separation tank, pump or pump and fluid maintenance package, waste holding tank and incinerator.

* Separation tank normally has two vertical compartments which can be furnished as two individual tanks. This may help placement in tight quarters.

Table 9

WMS COMPONENT RESOURCE REQUIREMENTS

WMS COMPONENTS	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air CFM	Fuel Oil (gph)	
Separation Tank (A, B/B, B)									
Macerator Pump Motor:	1-1/2		230	1	60				10 sec on, 2 min. off until level sensor in tank is satisfied.
	Optional		208	3	60				
			230	3	60				
			460	3	60				
Blower Motor	1/16		115	1	60		150		Continuous
Controls		250 max							
Pump & Fluid Maint. Sys. (A, A/B)									
Fluid Pump Motor (2)	2		115/230	1	60				One pump operates continuously - manual switchover
	Optional		208	3	60				
			230	3	60				
			460	3	60				
Flush Fluid Pump Pkg. (B)									
Fluid Pump Motor (2)	2		230	1	60				One pump operates continuously - manual switchover
	Optional		208	3	60				
			230	3	60				
			460	3	60				
Sludge Holding Tank (B, C)			230	1	60	11			
Recirculation Pump Motor	3/4								Runs about 20 minutes when level is high
Transfer Pump Motor	1/3								10 sec on, 2 min. off until level is satisfied
Blower Motor	1/16								
Incinerator (A)									
Fuel Pump/Blower Motor Unit			115	1	60	5	32	1.25	Operates during combustion sequence. Waste to fuel ratio 3:1
Incinerator (C)									
Fuel Pump/Blower Motor Units (2)			115	1	60	10	64	2.50	Operates during combustion sequence. Waste to fuel ratio 3:1
Sludge Ejection Tank			230	1	60	4			
Discharge Pump Motor	1/3								Operates once a day
Blower Motor	1/16								

Table 10

STANDARD COMPONENT PIPE CONNECTION SIZES

Chrysler WMS Components	
Separation Tank (for Models A, A/B, B)	
Waste Inlet:	4 in. NPT
Waste Outlet (Pump discharge)	1 in. NPT
Flush Fluid Outlet	1 1/2 in. NPT
Flush Fluid Return	1/2 in. NPT
Vent Blower Outlet	2 in.
Pump and Fluid Maintenance System (for Models A, A/B)	
Flush Fluid Inlet	1 1/2 in. NPT
Flush Fluid Supply	1 1/2 in. NPT
Bypass Fluid Return	1/2 in. NPT
Flush Fluid Pump Package (for Model B)	
Flush Fluid Inlet	1 1/2 in. NPT
Flush Fluid Supply	1 1/4 in. NPT
Fluid Maintenance Module (for Model B)	
Fluid Inlet	3/4 in. NPT
Bypass Fluid Return	1/2 in. NPT
Sludge Holding Tank (for Models B, C)	
Waste Inlet	1 in. NPT
Transfer Pump Outlet	1 in. NPT
Recirculation Pump Outlet	1 in. NPT
Vent Blower Outlet	2 in.
Incinerator (for Models A, A/B, B)	
Waste Inlet	1 in. NPT
Fuel Suction and Return	3/8 OD tubing
Stack	8 in. ID Metalbestos*
Incinerator (for Model C)	
Waste Inlet	1 in. NPT
Fuel Suction and Return	1/2 in. NPT
Stack	12 in. ID Metalbestos*
Sludge Ejection Tank	
Waste Inlet	1 in. NPT
Vent Blower Outlet	2 in.

*Stack may vary from connection size depending upon installation.

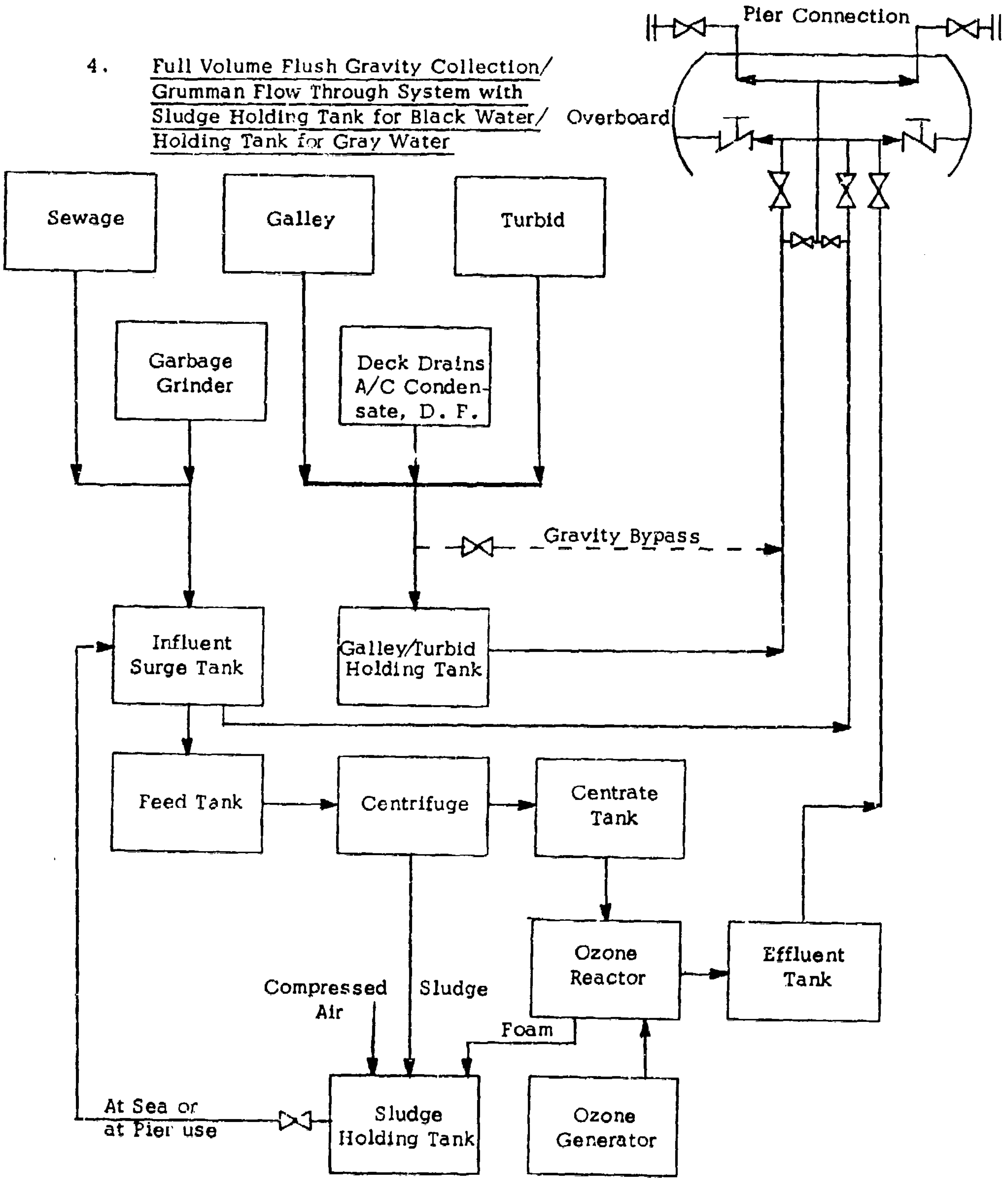
Table 11

MAXIMUM GRAY WATER HOLDING TANK VOLUMES

Vessel		Manning	Longest Hold. Time Required (Hrs)	gal	cu ft	Discharge Pump gpm
Gallatin	(378')	152	97.5	22,230	2,972	30
Vigorous	(210')	60	172.0	15,480	2,069	30
Firebush	(180')	50	277.9	20,843	2,786	30
White Sage	(133')	21	65.5	2,063	276	30
Pamlico (new construction)	(160')	13	501.0*	9,770	1,306	30
Point Herron	(82')	8	99.0	1,188	159	17

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

4. Full Volume Flush Gravity Collection/ Grumman Flow Through System with Sludge Holding Tank for Black Water/ Holding Tank for Gray Water



1. In this system sanitary waste, which includes ground garbage, is treated in a flow-through apparatus and gray water (galley and turbid) is retained in a holding tank for subsequent off-loading. The flow-through equipment is a modification of the Grumman WMS, developed for the Coast Guard, tested on the CGC Red Beech, and described in the Grumman Operation and Maintenance Instructions. The major components deleted are: the influent screen, disk centrifuge and the Grumman incinerator. The major components added are an influent surge tank, surge tank pump, sludge holding tank and a sludge transfer pump.

2. The flow-through system is designed for a steady influent rate of one gpm. Only one size (or capacity) system is currently available. Table 12 presents the number of systems required for each vessel, the hours of operation of each system, the expected volume of sludge per day and the maximum tank volume to retain the sludge generated during the longest stay in restricted waters, according to recorded mission profile data. The tank volumes include an additional 20% of the maximum liquid volume as safety margin.

Table 12

SYSTEM OPERATION AND VOLUMES OF TANKS

Vessel		Crew Size	Longest Holding Time Required (Hrs)	Total Flow gpd	No. of System	System Operation hr/day (each)	Sludge gpd	Sludge Holding Tank			Influent Surge Tank	
								gal	cu. ft.	Comp. Air SCFM	gal	cu. ft.
Gallatin	(378')	152	97.5	1596	2	13.3	133	648	87	8.6	793	106
Vigorous	(210')	60	172.0	630	1	10.5	53	452	60	6.1	313	42
Firebush	(180')	50	277.9	525	1	8.8	44	608	81	8.3	261	35
White Sage	(133')	21	65.5	220	1	3.7	18	60	8.0	0.8	110	15
Pamlico (under constr.)	(160')	13	501.0*	137	1	2.3	11	285	38	3.9	68	9
Point Herron	(82')	8	99.0	84	1	1.4	7	25	4.6	0.5	42	5.5

* Based on data from USCG's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

3. Urinals and commodes are the existing standard fixtures, supplied by the existing flush water (sea water) supply system. The sanitary sewer also receives wastes from the garbage grinder. The galley drain line and the sewer network for turbid wastes are separate from each other (and the sanitary drain) until they reach the gray water holding tank. Drain lines are standard sized, sloped drainage lines.

4. Sanitary wastes are collected in one (or more) black water surge tank(s) for batch transfer to the treatment system. The total volumes of the surge tank(s), including additional volume equal to 20% of the liquid as safety margin, are given in Table 12. The volumes were calculated as half the daytime flow, figuring that 80% of the black water is collected during the day. Wastes from the garbage grinder are assumed as generated during the day.

5. The surge tank pump is a solids handling type which will transfer sewage to the WMS 30-gallon feed tank. On the Gallatin, each of the flow-through treatment systems will have its own surge tank pump, whether one or two surge tanks are used. The pump(s) should be located with the tank(s) but tank and pump need not be located near or on the same level as the treatment system(s).

6. Located within the bounds of the Grumman system framework are the original 30-gallon feed tank, metering feed pump, basket centrifuge, centrate tank, centrate pump, ozone generator, ozone reactor, effluent tank and effluent pump. The sludge holding tank must be located near the ozone reactor but need not be within the Grumman System framework. It could be located on a deck below, provided the foam and centrifuge sludge can drain into it by gravity.

7. The sludge holding tank is aerated to prevent septic, odor generating conditions. Compressed air is supplied by the vessel's low pressure system. The compressed air flow rates given in Table 12 are based on 16.3 SCFM per 1000 gal of liquid. Pressure should nominally be 23-foot water column greater than the maximum depth of the holding tank.

8. During the system operation, the effluent pump periodically discharges a nominal 7 gpm at 20 psig from the 10-gallon effluent tank. The effluent is piped to a riser leading to the overboard discharge manifold. Where multiple WMS's are involved, they discharge to a common riser.

9. The physical characteristics of the modified Grumman main structure are 85 in H by 63 in L, by 76 in W, occupying 236 cu ft and weighing 3,056 lbs when filled. Resource requirements for the system are given in Table 13 and pipe connection sizes are given in Table 14.

10. A gray water holding tank receives galley and turbid (G/T) wastewater from drain lines that remain separate until reaching the holding tank. The maximum tank volumes required to hold all gray water generated during the longest stay in restricted waters, according to recorded mission profile data are given in Table 15. They include additional volume equal to 20% of maximum liquid volume as safety margin.

11. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. If the G/T drain manifold is above the waterline, provision can be made to bypass the holding tank. (The sanitary influent surge tank cannot be bypassed.) If the vessel configuration will not allow gravity drainage overboard, G/T wastes drain to the holding tank from which it can be pumped overboard. In those cases where the G/T holding tank capacity is less than that of the sludge holding tank in terms of hours, the G/T wastes can drain or be pumped overboard in restricted waters when the tank is full.

12. The WMS is bypassed in unrestricted waters by pumping black water overboard from the influent surge tank. To simplify riser piping and overboard pumping operations, collected sludge in the holding tank is transferred to the influent surge tank for disposal. Transfer can be effected by pumping if gravity flow is not possible. This method is also used for pumping to pier connections while tied up.

13. When the vessel is tied up, sanitary and G/T wastes are pumped to a pier connection. Since the sludge surge tank is small relative to the G/T holding tank, each tank has its own riser to the pier connection manifold. Valving permits isolation of lines and independent discharge.

14. The influent surge tank and the gray water holding tank will each have a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up to a minimum sized pipe riser of 1-1/2 inches. Nominal pump out time for each tank should be one hour if the resulting flow rate falls between these limits. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

Table 13

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air SCFM	Compressed Air SCFM	Fuel Oil gph	Cooling Water gpm
GAC System			120/208	3	60					
Feed Pump		400	115	1	60					
Basket Centrifuge	2		208	3	60					
Scoop Motor		115	120/208	1	60					
Ozone Generator		2100	120	3	60		2			1
Effluent Pump	1/3		115	1	60					
Centrate Pump	1/8		115	1	60					1/4
Surge Tank Pump	1-1/2		208	3	60					
Sludge Transfer Pump	*1-1/2		208	3	60					
Controls (GAC)		est. 200	120	1	60					

*Estimated

Table 14

COMPONENT PIPE SIZE CONNECTIONS

Influent Surge Tank Pump	Inlet: Outlet:	3 inch NPT 1-1/4 inch NPT
Centrifuge Scoop Discharge		1 inch ID hose
Ozone Reactor Foam Overflow		2 inch NPT

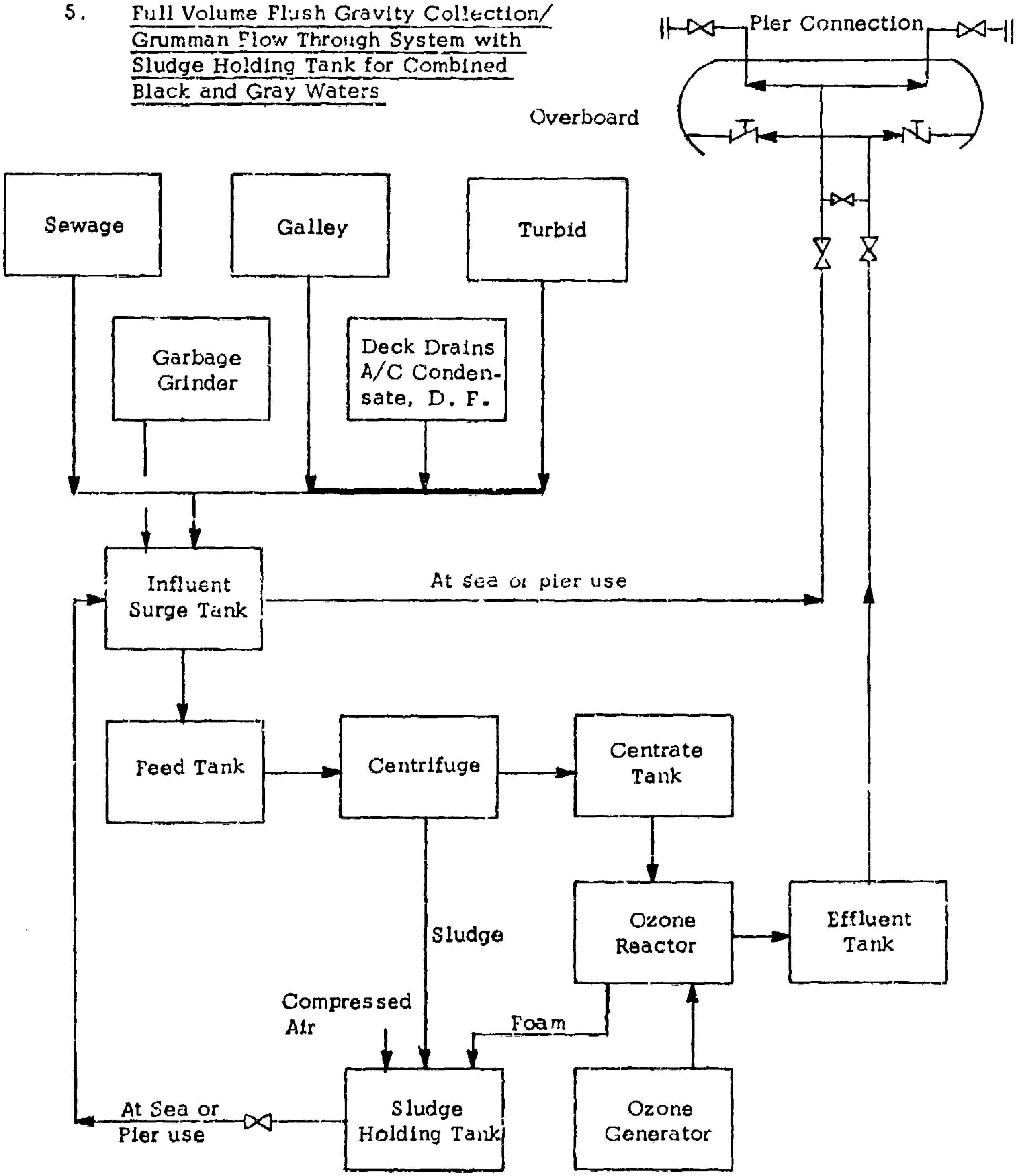
Table 15

MAXIMUM GRAY WATER HOLDING TANK VOLUMES

Vessel		Manning	Longest Hold. Time Required (Hrs)	gal	cu ft	Discharge Pump gpm
Gallatin	(378')	152	97.5	22,230	2,972	30
Vigorous	(210')	60	172.0	15,480	2,069	30
Firebush	(180')	50	277.9	20,843	2,786	30
White Sage	(133')	21	65.5	2,063	276	30
Pamlico (new construction)	(160')	13	501.0*	9,770	1,306	30
Point Herron	(82')	8	99.0	1,188	159	17

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

5. <u>Full Volume Flush Gravity Collection/ Grumman Flow Through System with Sludge Holding Tank for Combined Black and Gray Waters</u>



1. The system is a modification of the Grumman WMS, developed for the Coast Guard, tested on the CGC Red Beech, and described in the Grumman Operation and Maintenance Instructions. The major components deleted are: The influent screen, disk centrifuge and the Grumman incinerator. The major components added are: an influent surge tank, surge tank pump, sludge holding tank and a sludge transfer pump.

2. The flow through system is designed for a steady influent rate of one gpm. Only one size (or capacity) system is currently available. Table 16 presents the number of systems required for each vessel, the hours of operation of each system, the expected volume of sludge per day and the maximum tank volume to retain the sludge generated during the longest stay in restricted waters, according to recorded mission profile data. The tank volumes include an additional 20% of the maximum liquid volume as safety margin.

Table 16

SYSTEM OPERATION AND VOLUME OF TANKS

Vessel	Crew Size	Longest Holding Time Required (Hrs)	Total Flow gpd	No. of Systems	System Operation hr/day (each)	Sludge gpd	Sludge Holding Tank			Influent Surge Tank	
							gal	cu. ft.	Comp. Air SCFM	gal	cu. ft.
Gallatin (378')	152	97.5	6156	5	20.5	513	2501	334	34	3128	418
Vigorous (210')	60	172.0	2430	2	20.[illegible]	203	1742	233	24	1235	165
Firebush (180')	50	277.9	2025	2	16.[illegible]	169	2345	313	32	1029	138
White Sage (133')	21	65.5	851	1	14.2	71	332	31	3.2	432	58
Pamlico (160') (Under Constr.)	13	501.0*	527	1	8.[illegible]	14	1090	147	15	268	36
Point Herron (82')	8	99.0	324	1	5.4	27	134	18	1.8	165	22

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

3. Urinals and commodes are the existing standard fixtures, supplied by the existing flush water (sea water) supply system. The galley drain line and the sewer network for turbid wastes are separate and distinct from each other (and the sanitary drain) until they reach the influent surge tank. The drain line from the garbage grinder is separate from other sewers until reaching the influent surge tank or adjacent piping. Drain lines are standard sized, sloped drainage lines.

4. All wastes are collected in one (or more) influent surge tank(s) for batch transfer to the treatment system. The total volume of the surge tank(s), including additional volume equal to 20% of the liquid as safety margin, is given in Table 16. The volumes were calculated as half the daytime flow assuming that 80% of the turbid water and sewage, and all of the galley water and garbage slurry are collected during the day.

5. The surge tank pump is a solids handling type which will transfer sewage batch-wise to the WMS 30 gallon feed tank. Each flow through treatment system will have its own surge tank pump, whether the number of tanks is equal to or less than the number of systems. The pump(s) should be located with the tank(s) but they need not be located near or on the same level as the treatment systems.

6. Located within the bounds of the Grumman system framework are the original 30 gallon feed tank, metering feed pump, basket centrifuge, centrate tank, centrate pump, ozone generator, ozone reactor, effluent tank and effluent pump. The sludge holding tank must be located near the ozone reactor but need not be within the Grumman system framework. It could be located on a deck below, provided the foam and centrifuge sludge can drain into it by gravity.

7. The sludge holding tank is aerated to prevent septic, odor generating conditions. Compressed air is supplied by the vessel's low pressure system. The compressed air flow rates given in Table 16 are based on 16.3 SCFM per 1000 gal of liquid. Pressure should nominally be 23 ft water column greater than the maximum depth of the holding tank.

8. During system operation, the effluent pump periodically discharges a nominal 7 gpm at 20 psig from the 10-gallon effluent tank. The effluent is piped to a riser leading to the overboard discharge manifold. Where multiple WMS's are involved, they discharge to a common riser.

9. The physical characteristics of the modified Grumman main structure are 85 in H by 63 in L by 76 in W, occupying 236 cu ft and weighing 3056 lbs when filled. Resource requirements for the system are given in Table 17 and pipe connection sizes are given in Table 18.

10. The WMS is bypassed in unrestricted waters by pumping black water overboard from the influent surge tank. To simplify riser piping and overboard pumping operations, collected sludge in the holding tank is transferred to the influent surge tank for disposal. Transfer can be effected by pumping if gravity flow is not possible. This method is also used for pumping to pier connections while tied up. In the case of the Pamlico, off loading could be done from the sludge holding tank (with transfer from the influent surge tank) because of the large difference in tank sizes.

11. The influent surge tank (or the sludge holding tank on the Pamlico) has a discharge pump plus a backup pump installed. Since the present pier connections accept a maximum of 30 gpm, discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inch. Nominal pump out time for each tank should be one hour if the resulting flow rate falls between these limits. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

Table 17

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air SCFM	Compressed Air SCFM	Fuel Oil gph	Cooling Water gpm
GAC System			120/208	3	60					
Feed Pump		400	115	1	60					
Basket Centrifuge	2		208	3	60					
Scoop Motor		115	120/208	1	60					
Ozone Generator		2100	120/	3	60		2			1
Effluent Pump	1/3		115	1	60					
Centrate Pump	1/8		115	1	60					1/4
Surge Tank Pump	1-1/2		208	3	60					
Sludge Transfer Pump	1-1/2*		208	3	60					
Controls (GAC)		est. 200	120	1	60					

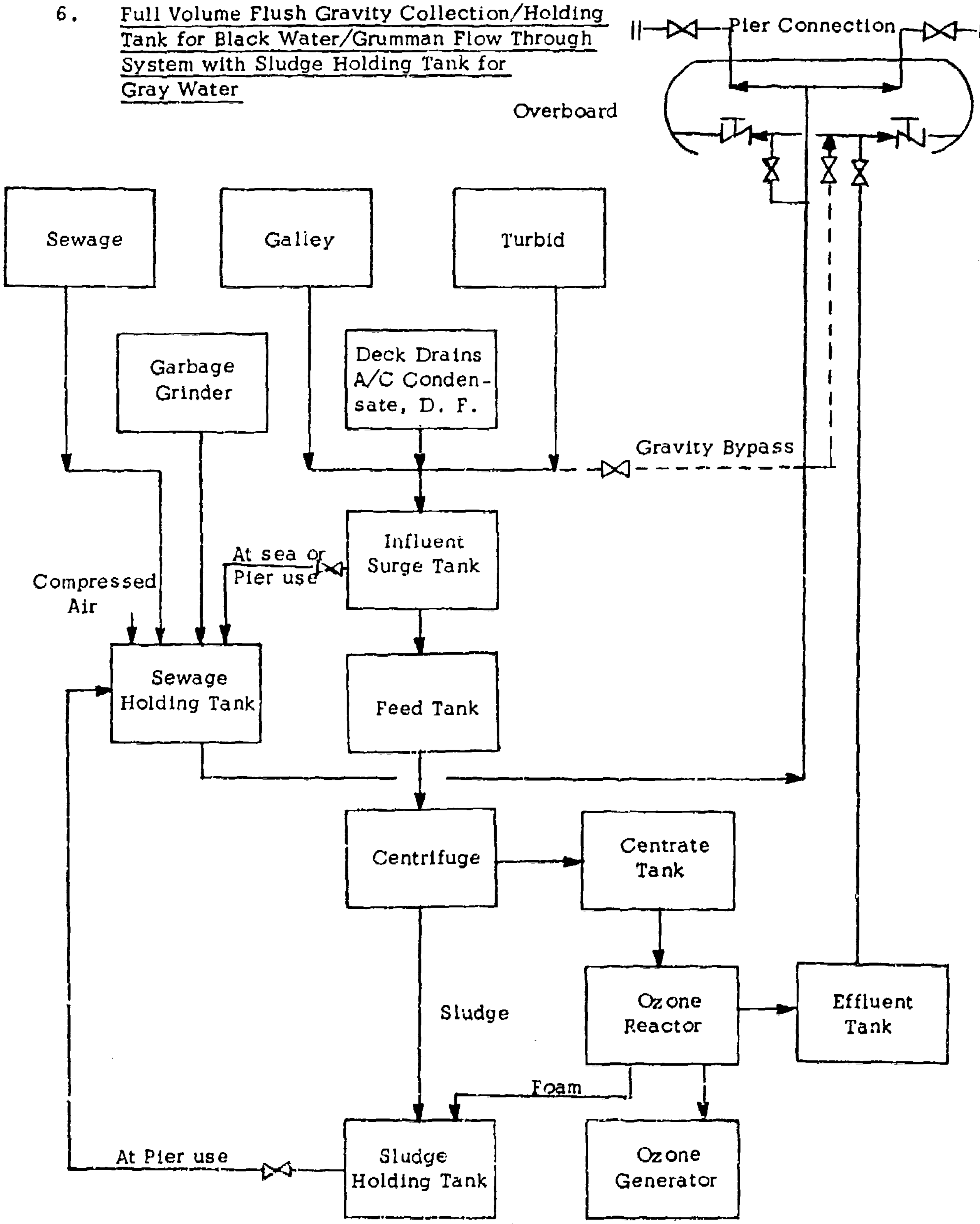
* Estimated.

Table 18

COMPONENT PIPE SIZE CONNECTIONS

Influent Surge Tank Pump	Inlet: 3 inch NPT Outlet: 1-1/4 inch NPT
Centrifuge Scoop Discharge	1 inch ID hose
Ozone Reactor Foam Overflow	2 inch NPT

6. <u>Full Volume Flush Gravity Collection/Holding Tank for Black Water/Grumman Flow Through System with Sludge Holding Tank for Gray Water</u>



1. In this system galley and turbid (G/T) waste is treated in a flow-through apparatus and sanitary wastes (including ground garbage slurry) is retained in a holding tank for subsequent off loading. The flow-through equipment is a modification of the Grumman WMS, developed for the Coast Guard, tested on the CGC Red Beech, and described in the Grumman Operation and Maintenance Instructions. The major components deleted are: the influent screen, disk centrifuge and the Grumman incinerator. The major components added are: an influent surge tank, surge tank pump, sludge holding tank and a sludge transfer pump.

2. The flow through system is designed for a steady influent rate of one gpm. Only one size (or capacity) system is currently available. Table 19 presents the number of systems required for each vessel, the hours of operation of each system, the expected volume of sludge per day and the maximum tank volume to retain the sludge generated during the longest stay in restricted water, according to recorded mission profile data. The tank volumes include an additional 20% of the maximum liquid volume as safety margin.

3. Urinals and commodes are the existing standard fixtures, supplied by the existing flush water (sea water) supply system. The sanitary sewer receives wastes from head spaces and conducts them to the sewage holding tank. Drain lines are standard sized, sloped drainage lines.

Table 19

SYSTEM OPERATION AND VOLUME OF TANKS

Vessel		Crew Size	Longest Holding Time Required (Hrs)	Total Flow gpd	No. of System	System Operation hr/day (each)	Sludge gpd	Sludge Holding Tank		Influent Surge Tank	
								gal	cu ft	gal	cu ft
Gallatin	(378')	152	97.5	4560	4	19.0	380	1853	248	2335	312
Vigorous	(210')	60	172.0	1800	2	15.0	150	1290	172	922	123
Firebush	(180')	50	277.9	1500	2	12.5	125	1737	232	768	103
White Sage	(133')	21	65.5	630	1	10.5	53	172	23	323	43
Pamlico (under constr.)	(160')	13	501.0 *	390	1	6.5	32	814	109	200	27
Point Heron	(82')	8	99.0	240	1	4.0	20	99	13	123	16

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements

4. Galley and turbid (G/T) wastes are collected in one (or more) influent surge tank(s) for batch transfer to the treatement system. The total volume of the surge tank(s), including additional volume equal to 20% of the liquid as safety margin, are given in Table 19. The volumes were calculated as half the daytime flow, figuring that 80% of the turbid water and all of the galley water is collected during the day.

5. The surge tank pump is a solids handling type which will transfer sewage batch-wise to the WMS 30-gallon feed tank. On vessels with multiple WMS, each system will have its own surge tank pump whether one or more surge tanks are used. The pumps should be located with the tank(s) but tank and pump need not be located near or on the same level as the treatment system(s).

6. Located within the bounds of the Grumman system framework are the original 30-gallon feed tank, metering feed pump, basket centrifuge, centrate tank, centrate pump, ozone generator, ozone reactor, effluent tank and effluent pump. The sludge holding tank must be located near the ozone reactor but need not be within the Grumman System framework. It could be located on a deck below, provided the foam and centrifuge sludge can drain into it by gravity.

7. During the system operation, the effluent pump periodically discharges a nominal 7 gpm at 20 psig from the 10-gallon effluent tank. The effluent is piped to a riser leading to the overboard discharge manifold. Where multiple WMS's are involved, they discharge to a common riser.

8. The physical characteristics of the modified Grumman main structure are 85 in H by 63 in L, by 76 in W, occupying 236 cu ft and weighing 3,056 lbs when filled. Resource requirements for the system are given in Table 20 and pipe connection sizes are given in Table 21.

9. The sewage holding tank receives sanitary wastes and ground garbage slurry. The maximum tank volumes required to hold all sewage generated during the longest stay in restricted waters, according to recorded mission profile data are given in Table 22. They include additional volume equal to 20% of maximum liquid volume as safety margin. The holding tank is aerated to prevent septic. odor generating conditions. Compressed air is supplied by the vessel's low pressure system. The compressed air flow rates given in Table 22 are based on 16.3 SCFM per 1000 gal of liquid. Pressure should nominally be 23 ft water column greater than the maximum depth of the holding tank.

Table 20

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air SCFM	Compressed Air SCFM	Fuel Oil gph	Cooling Water gpm
GAC System			120/208	3	60					
Feed Pump		400	115	1	60					
Basket Centrifuge	2		208	3	60					
Scoop Motor		115	120/208	1	60					
Ozone Generator		2100	120	3	60		2			1
Effluent Pump	1/3		115	1	60					
Centrate Pump	1/8		115	1	60					1/4
Surge Tank Pump	1-1/2		208	3	60					
Sludge Transfer Pump	*1-1/2		208	3	60					
Controls (GAC)		est.200	120	1	60					

*Estimated

Table 21

COMPONENT PIPE SIZE CONNECTIONS

Influent Surge Tank Pump	Inlet:	3 inch NPT
	Outlet:	1-1/4 inch NPT
Centrifuge Scoop Discharge		1 inch ID hose
Ozone Reactor Foam Overflow		2 inch NPT

10. A design option for the sewage holding tank and the sludge holding tank is to have both functions accommodated in a combined holding tank. Storage and off loading for both tanks are normally done at the same time. The combined function tank is 24% larger than the sewage holding tank. Compressed air flow would also be increased by 24%. If these functions remain separate, the sludge holding tank will be provided with a gravity drained or pumped connection to the sewage holding tank for use during off loading.

11. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. In order to simplify riser piping and overboard pumping operations, all wastes being collected or previously collected are pumped from the sewage holding tank (or the optional combined holding tank). The G/T influent surge tank is provided with a gravity drained or pumped transfer line for use in off loading.

12. The sewage holding tank (or combined holding tank) will have a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inches. Discharge pump flow rates are given in Table 22. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

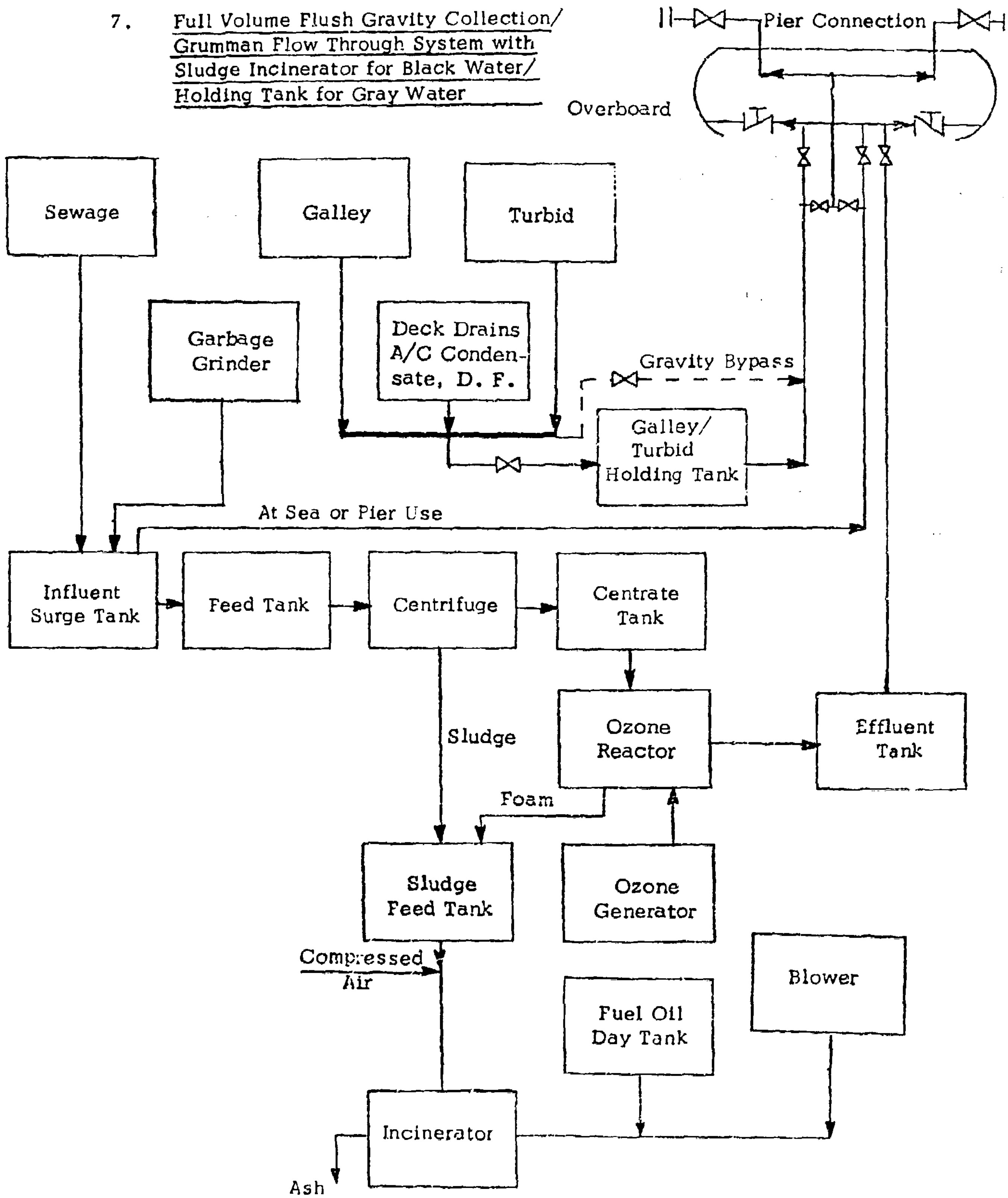
Table 22

SEWAGE HOLDING TANK

Vessel		Crew Size	Longest Holding Time Required (Hrs)	Sewage Flow gpd	Sewage Holding Tank			Discharge Pump gpm	Optional Combined Holding Tank		
					gal	cu ft	Comp. Air SCFM		gal	cu ft	Air SCFM
Gallatin	(378')	152	97.5	1596	7781	1040	106	30	9633	1288	131
Vigorous	(210')	60	172.0	630	5418	724	74	30	6708	897	91
Firebush	(180')	50	277.9	525	7295	975	99	30	9082	1207	123
White Sage	(133')	21	65.5	221	722	97	10	10	894	120	12
Pamlico (under constr.)	(160')	13	501.0*	137	3419	457	46	30	4233	566	57
Point Herron	(82')	8	99.0	84	41[illegible]	56	6	10	515	69	7

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

7. Full Volume Flush Gravity Collection/ Grumman Flow Through System with Sludge Incinerator for Black Water/ Holding Tank for Gray Water



1. In this system sanitary waste, which includes ground garbage, is treated in a flow through apparatus and gray water (galley and turbid) is retained in a holding tank for subsequent off loading. The flow-through equipment is a modification of the Grumman WMS, developed for the Coast Guard, tested on the CGC Red Beech, and described in the Grumman Operation and Maintenance Instructions. The major components deleted are: the influent screen, disk centrifuge and the Grumman incinerator. The major components added are: an influent surge tank, surge tank pump and a Thiokol incinerator subsystem. The subsystem is comprised of: an incinerator, sludge feed tank, sludge pump, high pressure blower, fuel oil day tank and pump.

2. The flow-through system is designed for a steady influent rate of one gpm. Only one size (or capacity) system is currently available. Table 23 presents the number of systems required for each vessel, the hours of operation of each system, the expected volume of sludge and the hours of operation of each incinerator.

Table 23

SYSTEM OPERATION AND INFLUENT TANK VOLUME

Vessel		Crew Size	Longest Holding Time Required (Hrs)	Total Flow gpd	No. of System	System Operation hr/day (each)	Sludge gpd	Incinerator Operation hr/day (each)	Influent Surge Tank	
									gal	cu ft
Gallatin	(378')	152	97.5	1596	2	13.3	133	11.1	793	106
Vigorous	(210')	60	172.0	630	1	10.5	53	8.8	313	42
Firebush	(180')	50	277.9	525	1	8.8	44	7.3	261	35
White Sage	(133')	21	65.5	220	1	3.7	18	3.1	110	15
Pamlico (under constr.)	(160')	13	501.0*	137	1	2.3	11	1.9	68	9
Point Herron	(82')	8	99.0	84	1	1.4	7	1.2	42	5.5

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

3. Urinals and commodes are the existing standard fixtures, supplied by the existing flush water (sea water) supply system. The sanitary sewer receives wastes from head spaces. The galley drain line and the sewer network for turbid wastes are separate from each oth (and the sanitary drain) until they reach the gray water holding tank. Drain lines are standard sized, sloped drainage lines.

4. Sanitary wastes are collected in one (or more) black water surge tank(s) for batch transfer to the treatment system. The total volumes of the surge tank(s), including additional volume equal to 20% of the liquid as safety margin, are given in Table 23. The volumes were calculated as half the daytime flow, figuring that 80% of the black water is collected during the day. Wastes from the garbage grinder are assumed as generated during the day.

5. The surge tank pump is a solids handling type which will transfer sewage to the WMS 30-gallon feed tank. On the Gallatin, each of the flow-through treatment systems will have its own surge tank pump, whe er one or two surge tanks are used. The pump(s) should be located with the tank(s) but tank and pump need not be located near or on the same level as the treatment system(s).

6. Located within the bounds of the Grumman system framework are the original 30 gallon feed tank, metering feed pump, basket centrifuge, centrate tank, centrate pump, ozone generator, ozone reactor, effluent tank and effluent pump. New equipment, entirely within the framework, are the sludge feed tank, sludge pump and incinerator blower. The incinerator is mostly within the confines of the Grumman structure and the shelf presently holding the disk centrifuge. The burner projects beyond the shelf. The incinerator control panel is mounted externally to the framework. A preliminary Thiokol arrangement sketch shows the location of the new incineration equipment modifying the Grumman design.

7. Beyond the confines of the flow-through system structure, several system components are required but not necessarily adjacent to or in the same compartment as the WMS. These are the influent surge tank and pump, previously mentioned and a fuel oil day tank with a recirculating oil feed pump (1.6 gph).

8. The effluent pump periodically discharges a nominal 7 gpm at 20 psig from the 10-gallon effluent tank. The effluent is piped to a riser leading to the overboard discharge manifold. Where multiple systems are involved, they discharge to one common riser.

9. A Thiokol flow diagram of the incineration subsystem depicts the relationship of the added components. This diagram is modified by a revised sludge flow schematic, substituting continuous sludge recirculation for bubble aeration in the sludge feed tank. A macerating pump will replace the Thiokol sludge pump. The drawings give interconnecting line sizes. Thiokol drawing 7U45700 gives the cross section of an IR & D Incinerator with a bill of materials. It is modified by the substitution of a high pressure Hauck burner as shown on the Outline Drawing of the Sludge Incinerator. Drawing 7U47822 gives dimensions and details of the Sludge Tank Assembly.

10. Physical characteristics of the main structure and peripheral components are given in Table 24. Resource requirements are given in Table 25. Pipe sizes of interconnecting lines between separately installed components are given in Table 26.

11. A gray water holding tank receives galley and turbid wastewater from drain lines that remain separate until reaching the holding tank. The maximum tank volumes required to hold all gray water generated during the longest stay in restricted waters, according to recorded mission profile data is given in Table 27. They include additional volume equal to 20% of maximum liquid volume as safety margin.

Table 24

WMS COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight (lbs)		Volume	Dimensions (inches)		
	Dry	Filled	(cu ft)	Height	Length	Width
Main Structure		4,380	236	85	63*	76†
Fuel Oil Day Tank		Δ150	3.3			
Fuel Oil Pump	est. 50					

* Plus 10 inches for control panel, 20 in W x 30 H

† Plus projection of incinerator nozzle.

Δ Weight of Oil alone.

Table 25

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air SCFM	Compressed Air SCFM	Fuel Oil gph	Cooling Water gpm
GAC System			120/208	3	60					
Basket Centrifuge	2		208	3	60					
Scoop Motor		115	120/208	1	60					
Ozone Generator		2,400	120/	3	60		2			1
Effluent Pump	1/3		115	1	60					
Centrate Pump	1/8		115	1	60					1/4
Blower	2		208	3	60					
		Opt.	460	3	60					
Incinerator		Opt.	460	3	60		100	12	1-1/2	
Fuel Oil Pump	est.1/4		120	1	60					
Sludge Pump	1-1/2		208	3	60					
Controls (GAC)		est. 200	120	1	60					
Controls (Thiokol)		est. 200	120	1	60					

Table 26

INTERCONNECTING PIPE SIZES

From	To	Size (inches)
Influent Surge Tank Pump	Feed Tank	2 NPT
Compressed Air Supply	Incinerator	1/2 NPT
Effluent Pump	Riser	3/4 to 1 NPT
Fuel Oil Pump	Incinerator	1/4 NPT
Incinerator	Atmosphere	7-1/2 ID x 14 OD* Insulated stack

*Stack may vary in size depending upon installation.

Table 27

MAXIMUM GRAY WATER HOLDING TANK VOLUMES

Vessel		Manning	Longest Hold. Time Required (Hrs)	gal	cu ft	Discharge Pump gpm
Gallatin	(378')	152	97.5	22,230	2,972	30
Vigorous	(210')	60	172.0	15,480	2,069	30
Firebush	(180')	50	277.9	20,843	2,786	30
White Sage	(133')	21	65.5	2,063	276	30
Pamlico (new construction)	(160')	13	501.0*	9,770	1,306	30
Point Herron	(82')	9	99.0	1,188	159	17

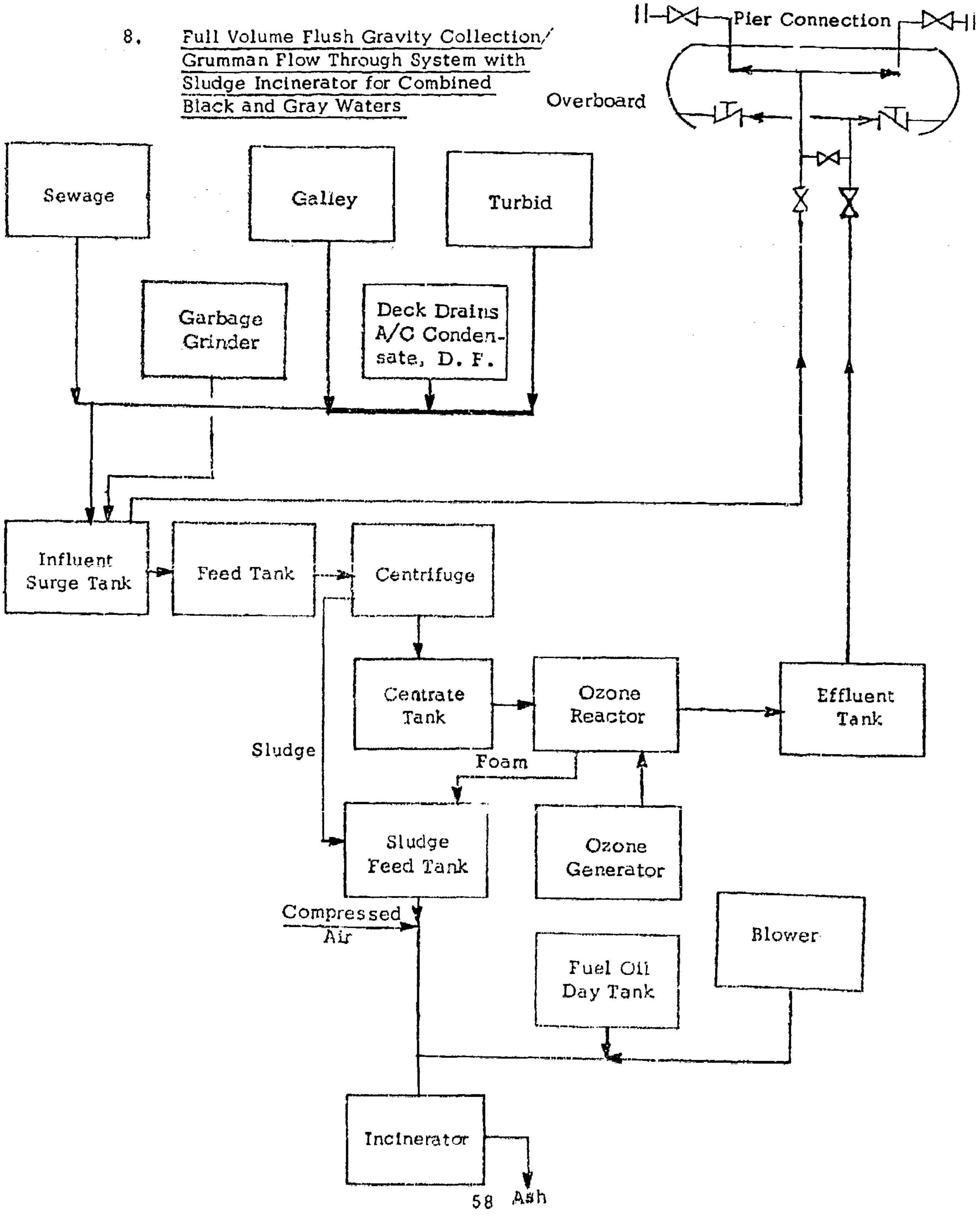
* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

12. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. If the G/T drain manifold is above the water-line, provision can be made to bypass the holding tank. (The sanitary influent surge tank cannot be bypassed.) If the vessel configuration will not allow gravity drainage overboard, G/T wastes drain to the holding tank from which it can be pumped overboard.

13. The WMS is bypassed in unrestricted waters by pumping black water overboard from the influent surge tank. When the vessel is tied up, sanitary and G/T wastes are pumped to a pier connection. Since the influent surge tank is small relative to the G/T holding tank, each tank has its own riser to the pier connection manifold. Valving permits isolation of lines and independent discharge.

14. The influent surge tank and the gray water holding tank will each have a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up to a minimum sized pipe riser of 1-1/2 inches. Nominal pump out time for each tank should be one hour if the resulting flow rate falls between these limits. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

8. Full Volume Flush Gravity Collection/ Grumman Flow Through System with Sludge Incinerator for Combined Black and Gray Waters



1. In this system, all hotel type wastes are treated in a flow-through apparatus. The system is a modification of the Grumman WMS, developed for the Coast Guard, tested on the CGC Red Beech, and described in the Grumman Operation and Maintenance Instructions. The major components deleted are: the influent screen, disk centrifuge and the Grumman incinerator. The major components added are: an influent surge tank, surge tank pump and a Thiokol incinerator subsystem. The subsystem is comprised of: an incinerator, sludge feed tank, sludge pump, high pressure blower, fuel oil day tank and pump.

2. The flow through system is designed for a steady influent rate of one gpm. Only one size (or capacity) system is currently available. Table 28 presents the number of systems required for each vessel, the hours of operation of each system, the expected volume of sludge and the hours of operation of each incinerator.

3. Urinals and commodes are the existing standard fixtures, supplied by the existing flush water (sea water) supply system. The galley drain line and the sewer network for turbid wastes are separate and distinct from each other (and the sanitary drain) until they reach the influent surge tank. Drain lines are standard sized, sloped drainage lines.

4. All wastes are collected in one (or more) influent surge tank(s) for batch transfer to the treatment system. The total volume of the surge tank(s), including additional volume equal to 20% of the liquid as safety margin, is given in Table 28. The volumes were calculated as half the daytime flow figuring that 80% of the turbid water and sewage, and all of the galley water and garbage slurry are collected during the day.

5. The surge tank pump is a solids handling type which will transfer sewage batch-wise to the WMS 30 gallon feed tank. Each flow through treatment system will have its own surge tank pump, whether the number of tanks is equal to or less than the number of systems. The pump(s) should be located with the tank(s) but they need not be located near or on the same level as the treatment systems.

Table 28

SYSTEM OPERATION AND INFLUENT TANK VOLUME

Vessel		Crew Size	Longest Holding Time Required (Hrs)	Total Flow gpd	No. of System	System Operation hr/day (each)	Sludge gpd	Incinerator Operation hr/day (each)	Influent Surge Tank gal	Influent Surge Tank cu ft
Gallatin	(378')	152	97.5	6,156	5	20.5	513	17.1	3,128	418
Vigorous	(210')	60	172.0	2,430	2	20.3	203	16.9	1,235	165
Firebush	(180')	50	277.9	2.025	2	16.9	169	14.1	1,029	138
White Sage	(133')	21	65.5	851	1	14.2	71	11.8	432	58
Pamlico (under constr.)	(160')	13	501.0 *	527	1	8.8	44	7.3	268	36
Point Herron	(82')	8	99.0	324	1	5.4	27	4.5	165	22

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

6. Located within the bounds of the Grumman system framework are the original 30 gallon feed tank, metering feed pump, basket centrifuge, centrate tank, centrate pump, ozone generator, ozone reactor, effluent tank and effluent pump. New equipment, entirely within the framework, are the sludge feed tank, sludge pump and incinerator blower. The incinerator is mostly within the confines of the Grumman structure and the shelf presently holding the disk centrifuge. The burner projects beyond the shelf. The incinerator control panel is mounted externally to the framework. A preliminary Thiokol arrangement sketch shows the location of the new incineration equipment modifying the Grumman design.

7. Beyond the confines of the flow through system structure, several system components are required but not necessarily adjacent to or in the same compartment as the WMS. These are the influent surge tank and pump, previously mentioned and a fuel oil day tank with a recirculating oil feed pump (1.6 gph).

8. The effluent pump periodically discharges a nominal 7 gpm at 20 psig from the 10 gallon effluent tank. The effluent is piped to a riser leading to the overboard discharge manifold. Where multiple systems are involved, they discharge to one common riser.

9. A Thiokol flow diagram of the incineration subsystem depicts the relationship of the added components. This diagram is modified by a revised

Table 29

WMS COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight (lbs)		Volume	Dimensions (inches)		
	Dry	Filled	(cu ft)	Height	Length	Width
Main Structure		4,380	236	85	63 *	76 †
Fuel Oil Day Tank		Δ150				
Fuel Oil Pump	est.50					

* Plus 10 inches for control panel, 20 in W x 30

† Plus projection of incinerator nozzle.

Δ Weight of Oil alone.

Table 30

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air SCFM	Compressed Air SCFM	Fuel Oil gph	Cooling Water gpm
GAC System			120/208	3	60					
Basket Centrifuge	2		208	3	60					
Scoop Motor		115	120	1	60					
Ozone Generator		2100	120/208	3	60		2			1
Effluent Pump	1/3		115	1	60					
Centrate Pump	1/8		115	1	60					1/4
Blower	2		208	3	60					
		Opt.	460							
Incinerator		Opt.	460	3	60		100	12	1-1/2	
Fuel Oil Pump	est.1/4		120	1	60					
Sludge Pump	1-1/2		208	3	60					
Controls (GAC)		est.200	120	1	60					
Control, (Thiokol)		est.200	120	1	60					

sludge flow schematic, substituting continuous sludge recirculation for bubble aeration in the sludge feed tank. A macerating pump will replace the Thiokol sludge pump. The drawings give interconnecting line sizes. Thiokol drawing 7U45700 gives the cross section of an IR & D Incinerator with a bill of materials. It is modified by the substitution of a high pressure Hauck burner as shown on the Outline Drawings of the Sludge Incinerator. Drawing 7U47822 gives dimensions and details of the Sludge Tank Assembly.

10. Physical characteristics of the main structure and peripheral components are given in Table 29. Resource requirements are given in Table 30. Pipe sizes of interconnecting lines between separately installed components are given in Table 31.

11. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. The WMS is bypassed by pumping wastes overboard from the influent surge tank. When the vessel is tied up, sanitary and galley/turbid waters are pumped from the surge tank to the pier connection.

12. The influent surge tank has a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inches. Nominal pump out time should be one hour if the resulting flow rate falls between these limits. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

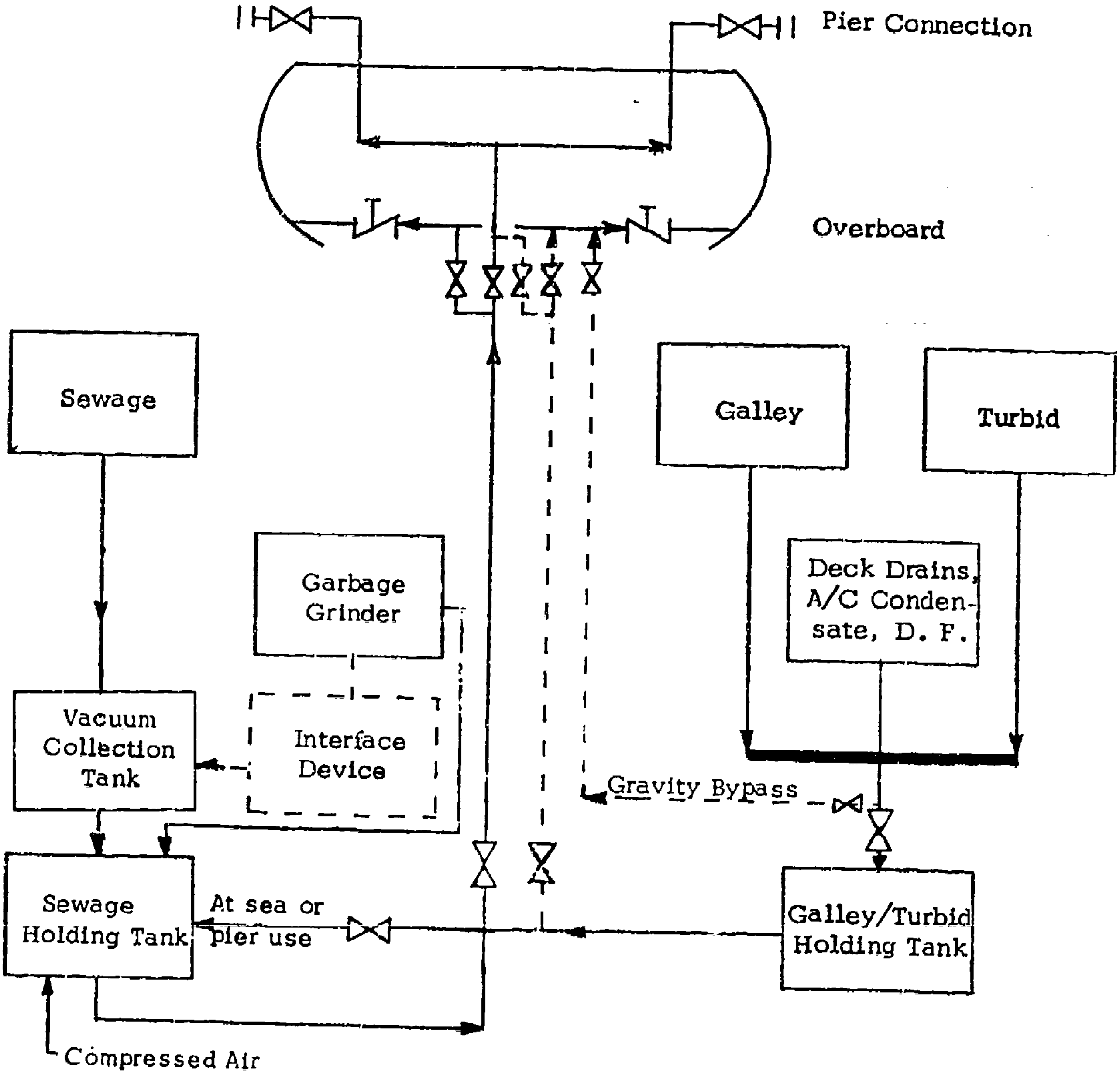
Table 31

INTERCONNECTING PIPE SIZES

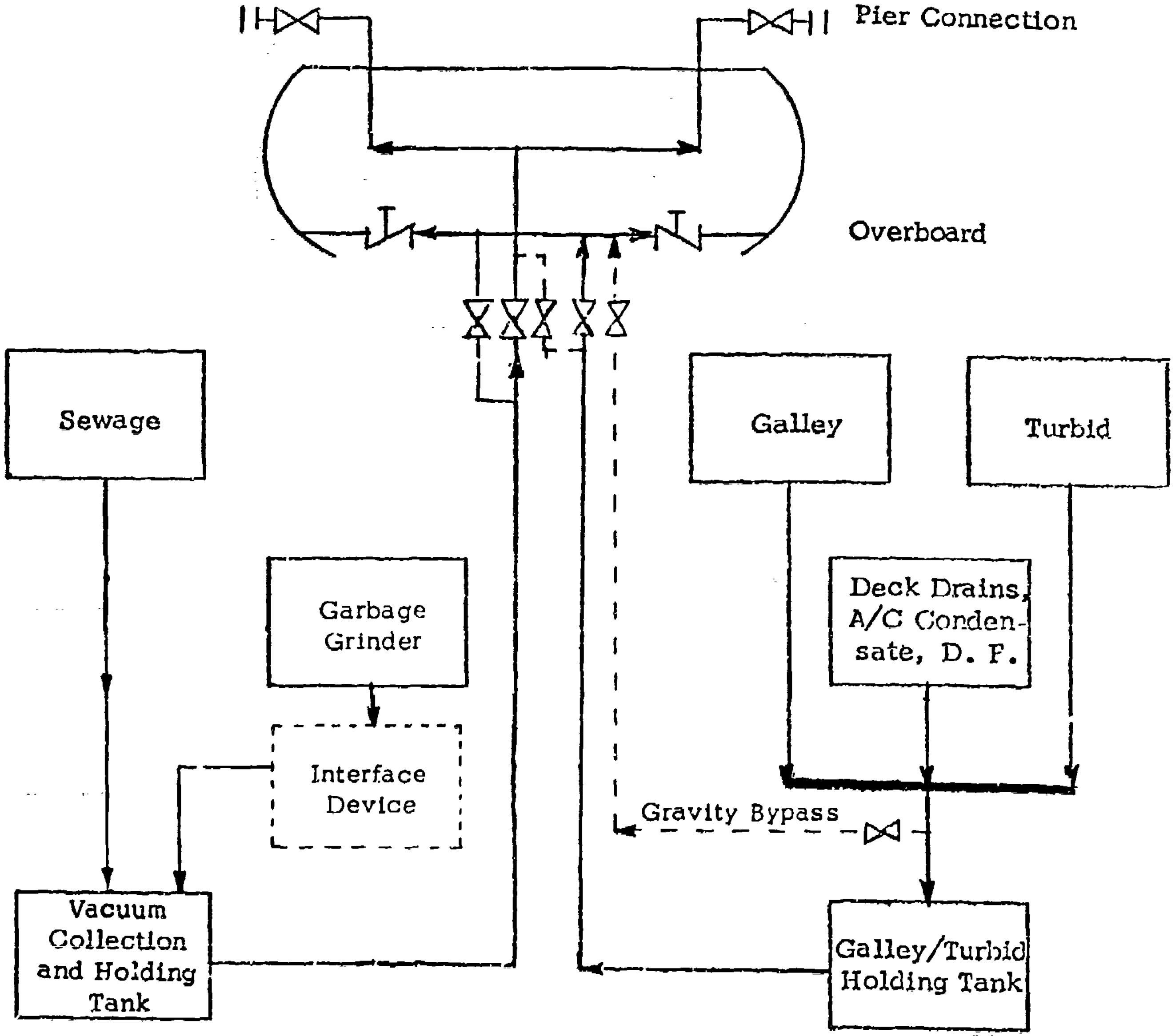
From	To	Size (inches)
Influent Surge Tank Pump	Feed Tank	2 NPT
Effluent Pump	Riser	3/4 to 1 NPT
Fuel Oil Pump	Incinerator	1/4 NPT
Incinerator	Atmosphere	7-1/2 ID x 14 OD* Insulated stack

*Stack may vary in size depending upon installation.

9a. JERED Reduced Volume Flush Vacuum Collection/Holding Tank for Concentrated Black Water/Holding Tank for Gray Water



9b. JERED Reduced Volume Flush Vacuum Collection/Concentrated Black Water Held in VCT/Holding Tank for Gray Water



1. This system provides no waste treatment but retains all wastes in holding tanks for subsequent off loading. It differs from System 1 in that reduced flush commodes and vacuum collection of sanitary wastes are used. Two minor system variations are shown in the flow diagrams: (9a) the vacuum collection tank (VCT) feeds a separate, vented holding tank and (9b) the VCT also serves as the black water holding tank.

2. Existing commodes are replaced by special vacuum operated units that occupy the same nominal volume. Existing urinals are retained. The flush medium is changed from sea water to fresh water. Drain lines from the commodes are replaced by vacuum tight 1-1/2 inch lines. The flow in these lines can be horizontal, sloped upward at a few degrees or even up a vertical rise of less than six feet.

3. Urinals drain by gravity to an interface valve which can service up to five urinals. This valve, the urine discharge valve, is normally installed in the head space. It momentarily connects the vacuum, which is downstream of the valve, to the gravity filled line upstream of the valve. It is self-powered, float operated. When the liquid level rises sufficiently, the float opens an orifice to vacuum which pulls the urine through. After the liquid level drops, the float reseals the orifice.

4. Garbage grinder slurry can drain by gravity to the holding tank or be picked up by the vacuum collection subsystem for subsequent transfer to the holding tank. The choice will be affected by the relative locations of the garbage grinder and the sewage holding tank. An interface device is required for getting the ground garbage into the vacuum line. Options for the device are (1) an automatic gray water

valve which is similar to the urine discharge valve, (2) vented tank, (3) open drum. The latter two drain through a manual or remotely operated valve. Assuming no more than 40% of the daily ground garbage flow being generated at one mealtime, the tank or drum volume (including 20% extra for safety margin) would be sized at 0.72 gal per capita.

5. Two general styles of vacuum collection equipment have been produced and are available from JERED Industries. The small boat style is oriented towards private cabin cruisers, yachts and charter fishing boats. The equipment tends to be lighter, smaller, and less durable. Smaller components are usually not designed for maintenance; defective parts are replaced rather than repaired. Where the operational requirements are not severe, the equipment can provide more than adequate service. Tank sizes available are 30, 60, 120 and 200 gallons with liquid capacities of 20, 50, 100 and 167 gallons, respectively. All sizes are normally provided with one Gast 0822 vacuum pump (oil lubricated, sliding vane). Manual valving permits the pump to pressurize the vacuum tank to blow out the contents. With a duplicate vacuum pump in parallel, all systems are adequate for continual use by a crew of 16. By substituting Gast 1022 vacuum pumps, system capacity can be increased to 21 men. Pump models are almost identical except for motor rating. Although the small boat systems are normally installed with flexible hose between components, the fittings will permit rigid piping.

6. The other style of vacuum collection equipment has been used for naval ships and similar heavy usage applications. The equipment tends to be heavier, stronger, more complex and designed for maintenance accessibility. Only one size will be required for the three

larger vessels in this study: the V85003, installed singly on the USS Kraus and in duplicate on the USS Spruance. The 250-gallon VCT, holding approximately 200 gallons, is furnished with water ring seal vacuum pumps, capable of continuous service for 200 men. Since System 9 does not incinerate collected sewage (and garbage slurry), the 5 HP Maz-O-Rator pump (270 lbs) is eliminated from the VCT package. The incinerator feed pump is designated as a standby for the effluent discharge pump.

7. Selections for black water collection plus holding tanks and one optional combined collection/holding tank for the Point Herron are given in Table 32. The maximum storage volumes (total of VCT and holding tank) are based on assumed flow rates and the longest stay in restricted waters, according to mission profile data. They provide additional volume equal to 20% of maximum liquid volume as safety margin in the storage tank or as vacuum reservoir in the VCT. Option (b) for the Point Herron is reflected in diagram 9b. The problems associated with pulling a vacuum in a storage tank and emptying the contents are minimal in a small tank. They are partially offset by the problems of aerating a small vented tank.

Table 32

MAXIMUM VOLUMES OF BLACK WATER TANKS

Vessel		Manning	Longest Holding Time Required (Hrs)	Option	VCT		Holding Tank			
					Size gal	Vacuum Pumps	Maximum Volume gal	Maximum Volume cu ft	Discharge Pump gpm	Compressed Air SCFM
Gallatin	(378')	152	97.5	a	250	WRS	2300	307	30	31
Vigorous	(210')	60	172.0	a	250	WRS	1540	206	24	21
Firebush	(180')	50	277.9	a	250	WRS	2145	287	30	29
White Sage	(133')	21	65.5	a	30	1022	200	27	10	2.7
Pamlico (Under Constr.)	(160')	[illegible]	501.0*	a	30	0822	1070	143	15	15
Point Herron	(82')	8	99.0	a	30	0822	[illegible]	13.9	10	1.4
				b	200	0822	-	-	-	-

WRS = water ring seal type, included in VCT assembly.

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements

8. In a vented holding tank used for sewage, aeration is required to prevent septic, odor generating conditions. Compressed air is supplied by the vessel's low pressure system. The flow rates, given in Table 32 for the maximum volume tank are based on 16.5 SCFM of air per 1000 gal of liquid. Pressure should nominally be 23 ft water column greater than the maximum depth of the holding tank. If tank size is less than maximum, air flow rate is reduced proportionately. Aeration is not required for a vacuum collection/storage tank since generated odors are removed by the vacuum pumps.

9. Physical characteristics of the equipment are given in Table 33, resource requirements in Table 34 and piping sizing in Table 35.

Table 33

COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight (lbs)		Volume	Dimensions (inches)		
	Dry	Filled	(cu ft)	Height	Length	Width
Commode	30	31	3.1	16.3	20.3	16
Urine Dischg. Valve	7	8	0.2	12.4	..	5.6 dia
Vac. Collect. Tank*						
30 gal	57	223	4.4	-	38	16 dia
200 gal	542	1927	33.5	-	72	32 dia
Vacuum Pump						
0822	43	-	1.0	18	10	10
1022	47	-	1.1	19	10	10
Vac. Collect. Assy.						
250 gal	5000	6900	165	66	72	60

* Includes tank and auxiliary components except for vacuum pump(s).

Table 34

WMS COMPONENT RESOURCE REQUIREMENTS *

Component	HP	Watts	Volts	Phase	Hertz	Amp
Vacuum Pump **						
0822	1/2		120/240	1	60	
1022	3/4		120/240	1	60	
Vacuum Collect. Assy.						
Vacuum Pump **	3		440	3	60	
Overboard Pump	3		440	3	60	
Effluent Pump	1/2		440	3	60	
Controls		250 est.	120	1	60	

* For compressed air, see Table 32

** Dual vacuum pumps frequently run at the same time.

Table 35

COMPONENT PIPE CONNECTION OR SIZE

Commode	Outlet Pipe Water Supply	1 1/2 in IPS 1/2 in ID Hose
Urinal Discharge Valve	Inlet and Outlet	1 1/2 in IPS
Vacuum Tanks (30, 60, 120, 200 gal)	Inlet and Outlet Vacuum Connection	2 in NPT
250 gal	See JEI ED Dwg. H20118C001	(3 sheets)
Vacuum Pump 0822 and 1022	Inlet and Outlet	3/8 in IPS

10. A gray water holding tank receives galley and turbid (G/T) wastewater from gravity drain lines that remain separate until reaching the holding tank. The maximum tank volumes required to hold all gray water generated during the longest stay in restricted waters, according to recorded mission profile data, is given in Table 36. They include additional volume equal to 20% of maximum liquid volume as safety margin.

Table 36

MAXIMUM GRAY WATER HOLDING TANK VOLUMES

Vessel		Manning	Longest Hold. Time Required (Hrs)	gal	cu ft	Discharge Pump gpm
Gallatin	(378')	152	97.5	22,230	2,972	30
Vigorous	(210')	60	172.0	15,480	2,069	24
Firebush	(180')	50	277.9	20,843	2,786	30
White Sage	(133')	21	65.5	2,063	276	10
Pamlico (new construction)	(160')	13	501.0*	9,770	1,306	15
Point Herron	(82')	8	99.0	1,188	159	Option a:10 Option b:17

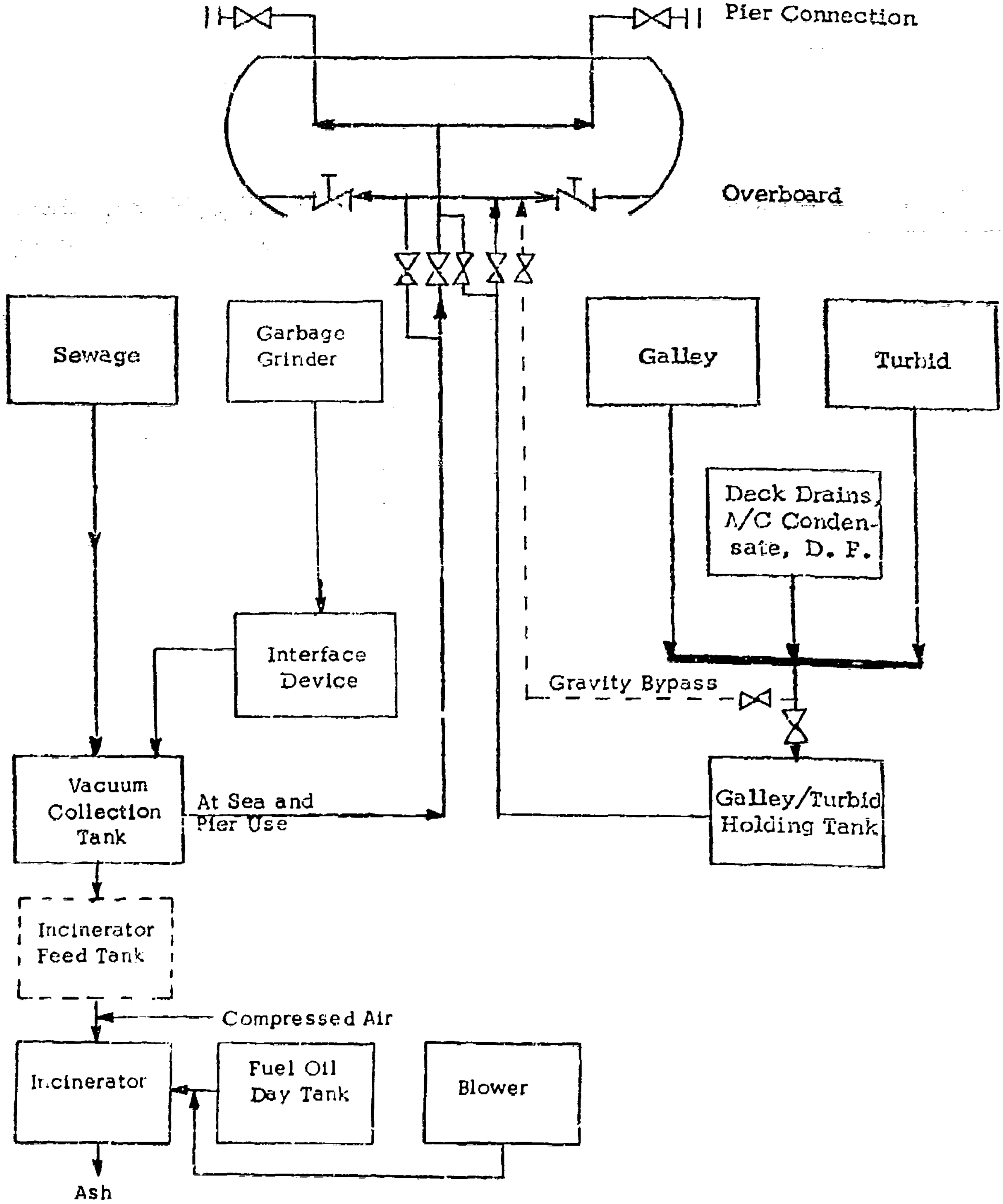
* Based on data from USCG's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

11. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. If the G/T drain manifold is above the waterline, a gravity bypass drain line will be installed to conduct wastewater to the overboard scuppers. If a gravity bypass is not feasible, gray water will be pumped from the G/T holding tank to the sewage holding tank and then pumped overboard. This latter arrangement is also used for off loading collected wastes to a pier connection, except for Option (b) on the Point Herron. In that case (diagram 9b), the sewage vacuum/ holding tank is blown by compressed air to either pier connection or overboard. Because of the pressure cycles and the disparate sizes the G/T holding tank has a separate riser to the pier connection and overboard manifolds.

12. For the situation where the G/T holding tank does not match the sewage holding tank in terms of retention time, and a gravity bypass is not feasible, a separate riser is installed between the tank discharge line and the overboard manifold. This permits dumping of gray water in restricted zones when the tank is full.

13. Each holding tank will have a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based on a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inches. Nominal pump out time for each tank should be one hour if the resulting flow rate falls between these limits. However, because of the relatively small volumes of the sewage holding tanks on the three smaller vessels and the transfer sequence for off loading, the discharge pumping rate for the gray water tanks should be reduced to that of the sewage discharge pumping rate.

10. JERED Reduced Volume Flush Vacuum Collection/Incinerator for Concentrated Black Water/Holding Tank for Gray Water



1. This system collects sanitary wastes and garbage slurry from a garbage grinder via a vacuum sewerage system and incinerates it. Black water volume is minimized by use of reduced flush, vacuum operated commodes.

2. Existing commodes are replaced by the special units that occupy the same nominal volume. Existing urinals are retained. The flush medium is changed from sea water to fresh water. Drain lines from the commodes are replaced by vacuum tight 1-1/2 inch lines. The flow in these lines can be horizontal, sloped upward at a few degrees or even up a vertical rise of less than six feet.

3. Urinals drain by gravity to an interface valve which can service up to five urinals. This valve, the urine discharge valve, is normally installed in the head space. It momentarily connects the vacuum, which is downstream of the valve, to the gravity filled line upstream of the valve. It is self-powered, float operated. When the liquid level rises sufficiently, the float opens an orifice to vacuum which pulls the urine through. After the liquid level drops, the float reseals the orifice.

4. An interface device is required for getting the ground garbage into the the vacuum line. Options for the device are (1) a gray water valve which is similar to the urine discharge valve, (2) vented tank, (3) open drum. The latter two drain through a manual or remotely operated valve. Assuming no more than 40% of the daily ground garbage flow being generated at one mealtime, the tank or drum volume (including 20% extra for safety margin) would be sized at 0.72 gal per capita.

5. Two general styles of vacuum collection equipment have been produced and are available from JERED Industries. The small boat style is oriented towards private cabin cruisers, yachts and charter fishing boats. The equipment tends to be lighter, smaller, and less

durable. Smaller components are usually not designed for maintenance; defective parts are replaced rather than repaired. Where the operational requirements are not severe, the equipment can provide more than adequate service. Tank sizes available are 30, 60, 120 and 200 gallons with liquid capacities of 20, 50, 100 and 167 gallons, respectively. All sizes are normally provided with one Gast 0822 vacuum pump (oil lubricated, sliding vane). Manual valving permits the pump to pressurize the vacuum tank to blow out the contents. With a duplicate vacuum pump in parallel, all systems are adequate for continual use by a crew of 16. By substituting Gast 1022 vacuum pumps, system capacity can be increased to 21 men. Pump models are almost identical except for motor rating. Although the small boat systems are normally installed with flexible hose between components, the fittings will permit rigid piping.

6. The other style of vacuum collection equipment has been used for naval ships and similar heavy usage applications. The equipment tends to be heavier, stronger, more complex and designed for maintenance accessibility. Only one size will be required for the three larger vessels in this study: the V85003, installed singly on the USS Kraus and in duplicate on the USS Spruance. The 250-gallon VCT, holding approximately 200 gallons is furnished with water ring seal vacuum pumps capable of continuous service for 200 men.

7. Only one size of JERED incinerator is currently available. It is rated to burn 30 gph of slurry with a maximum of 4% solids. The percentage of solids in the feed is expected to range from 2-1/2 to 3%.

A combustion air blower is provided in the skid-mounted incinerator assembly. Only one size of Thiokol incinerator subsystem is currently available, rated to burn 6 gph of sewage sludge. This subsystem was originally designed for use with another WMS installed on the CGC Red Beech. It is comprised of the incinerator, sludge tank, high pressure blower (for combustion air) recirculating sludge pump, oil day tank and pump, and electrical control box.

8. A Thiokol flow diagram of the incineration subsystem depicts the relationship of the components. This diagram is modified by a revised sludge flow schematic, substituting continuous sludge recirculation for bubble flow aeration in the sludge feed tank. The drawings give interconnecting line sizes. Thiokol drawing 7U45700 gives the cross section of an IR & D Incinerator with a bill of materials. It is modified by the substitution of a high pressure Hauck burner as shown on the Outline Drawing of the Sludge Incinerator. Drawing 7U47822 gives dimensions and details of the Sludge Tank Assembly. The peripheral equipment should be located in the general vicinity but not necessarily adjoining the incinerator.

9. The selections of vacuum collection tank and make of incinerator are presented in Table 37 along with incinerator burn time and fuel oil day tank volumes. The three larger vessels receive the heavy duty Jered VCT and the Jered incinerator. The three smaller vessels receive the Jered small boat VCT and the Thiokol incinerator. To the small boat VCT is added a recirculating macerator pump (the heavy duty VCT already has one). The macerating pump reduces particulate size to prevent incinerator nozzle clogging. It could optionally transfer sewage to the sludge tank instead of having the vacuum pump pressurize the VCT for blowing out the contents. The VCT's for the Pamlico and Point Herron were sized to permit incinerator operation every other day in order to avoid firing up infrequently for short periods of time. This is thermally more efficient and helps prolong the life of the incinerator.

Table 37

VCT AND INCINERATOR SELECTIONS AND BURN TIME

Vessel		Manning	Longest Holding Time Required (Hrs)	Black Water Flow gpd	VCT Size gal	VCT Vacuum Pumps	Incineration Burn Time (hour/day)	Fuel Oil Day Tank Volume (cu ft)
Gallatin	(378')	152	97.5	513	250	WRS	17.1 J	20.6
Vigorous	(210')	60	172.0	203	250	WRS	6.8 J	8.2
Firebush	(180')	50	277.9	169	250	WRS	5.6 J	6.7
White Sage	(133')	21	65.0	71	120	1022	11.8 T	3.0
Pamlico (Under Constr.)	(160')	13	501.0**	44	120	0822	7.3* T	3.8
Point Herron	(82')	8	99.0	27	60	0822	4.5* T	2.3

WRS = Water Ring Seal Type, included in VCT assembly.
J = Jered incinerator
T = Thiokol incinerator
* = Every second day

** Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

10. Physical characteristics of system components are given in Table 38 and vessel resource requirements in Table 39. Pipe connections or pipe sizes are given in Table 40.

11. A gray water holding tank receives galley and turbid wastewater from drain lines that remain separate until reaching the holding tank. The maximum tank volumes required to hold all gray water generated during the longest stay in restricted waters, according to mission profile data, is given in Table 41. They include additional volume equal to 20% of maximum liquid volume as safety margin.

Table 38

COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight (lbs)		Volume	Dimensions (inches)		
	Dry	Filled	cu ft	Height	Length	Width
Commode	30	31	3.1	16.3	20.3	16 dia
Urine Dischg. Valve	7	8	0.2	12.4	-	5.6 dia
Vac. Collect. Tank*						
60 gal	175	591	8.7	-	48	20 dia
120 gal	350	1183	18.1	-	69	24 dia
Vacuum Pump						
0822	43	-	1.0	18	10	10
1022	47	-	1.1	19	10	10
Recirc. Macer. Pump**	125	127	1.0	10	25	7
Incin. Feed Pump **	144	147	2.5	16	30	9
Vac. Coll. Tank Assy.						
250 gal	5000	6900	165	66	72	60
Incinerator (Jered)	2000	-	102	63	77	36
Incinerator (Thiokol)	800	-	23.8	40	49	21
Blower	260	-	11.0	24	36	22
Sludge Tank	50	220	6.5	31	30	12
Control Box	125	-	3.5	30	20	10
Fuel Oil Day Tank						
Gallatin		Δ960	20.6			
Vigorous		Δ382	8.2			
Firebush		Δ315	6.7			
White Sage		Δ140	3.0			
Pamlico		Δ177	3.8			
Point Herron		Δ107	2.3			

* Includes tank and auxiliary components except for vacuum pump(s)

** Included in 250 gal VCT Assembly.

Δ = Weight of oil.

Table 39

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air SCFM	Compressed Air SCFM	Fuel Oil gph
Vacuum Pump *									
0822	1/2		120/240	1	60				
1022	3/4		120/240	1	60				
Vacuum Collection Assy.									
Vacuum Pump *	3		440	3	60				
Overboard Pump	3		440	3	60				
Effluent Pump	1/2		440	3	60				
Controls		250 est.	120	1	60				
Recirc. Macerator Pump	1 1/2		440	3	60				
Incinerator (JERED)						10 max		15	
			110	1	60	1.0			
Blower	5		440	3	60		2700**		
Oil Pump	1/3		440	3	60				7.5 est.
Controls		250 est.	110	1	60				
Incinerator (Thiokol)			208	3	60				
		Opt	460	3	60				
Blower	2		208	3	60		100	12	1.6
		Opt	460	3	60				
Fuel Oil Pump	est 1/4		120	1	60				
Sludge Pump	1/4		120	1	60				
Controls		est. 200	120	1	60				

* Dual vacuum pumps frequently run at the same time.

** Combustion blower withdraws 720 SCFM. Compartment ventilation required is 2700 SCFM (per incinerator).

Table 40

COMPONENT PIPE CONNECTION OR SIZE

Commode	Outlet Pipe:	1 1/2-inch IPS
	Water Supply:	1/2-inch ID Hose
Urinal Discharge Valve	Inlet and Outlet:	1 1/2-inch IPS
Vacuum Tanks		
30 gal	Inlet and Outlet:	2-inch NPT
	Vacuum Connection	
250 gal	See JERED Dwg. H20118C001 (3 sheets)	
Vacuum Pump		
0822 and 1022	Inlet and Outlet:	3/8-inch IPS
Recirc. Macerator Pump	Inlet:	3-inch NPT
	Outlet:	1 1/4-inch NPT
Incinerator Feed Pump	Vertical:	1 1/2-inch NPT
	Horiz	1 1/4-inch NPT
	(Flow in either direction)	
Incinerator (JERED)		
Sludge Connection	1/2-inch NPT	
Compressed Air	1/4-inch NPT	
Stack	8-inch 150-lb steel flange*	
Incinerator (Thiokol)		
Blower Connection	2-1/2 inch NPT	
Sludge Connection	1/2 inch NPT	
Compressed Air	1/2 inch NPT	
Stack	7-1/2 inch ID x 14OD insulated stack*	
Sludge Tank Inlet	1 inch flange	
Outlet	1 inch flange	
Blower	2-1/2 inch NPT	

*Stack may vary in size depending upon installation

Table 41

MAXIMUM GRAY WATER HOLDING TANK VOLUMES

Vessel		Manning	Longest Hold. Time Required (Hrs)	gal	cu ft	Discharge Pump gpm
Gallatin	(378')	152	97.5	22,230	2,972	30
Vigorous	(210')	60	172.0	15,480	2,069	30
Firebush	(180')	50	277.9	20,843	2,786	30
White Sage	(133')	21	65.5	2,063	276	30
Pamlico (new construction)	(160')	13	501.0*	9,770	1,306	30
Point Herron	(82')	8	99.0	1,188	159	17

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

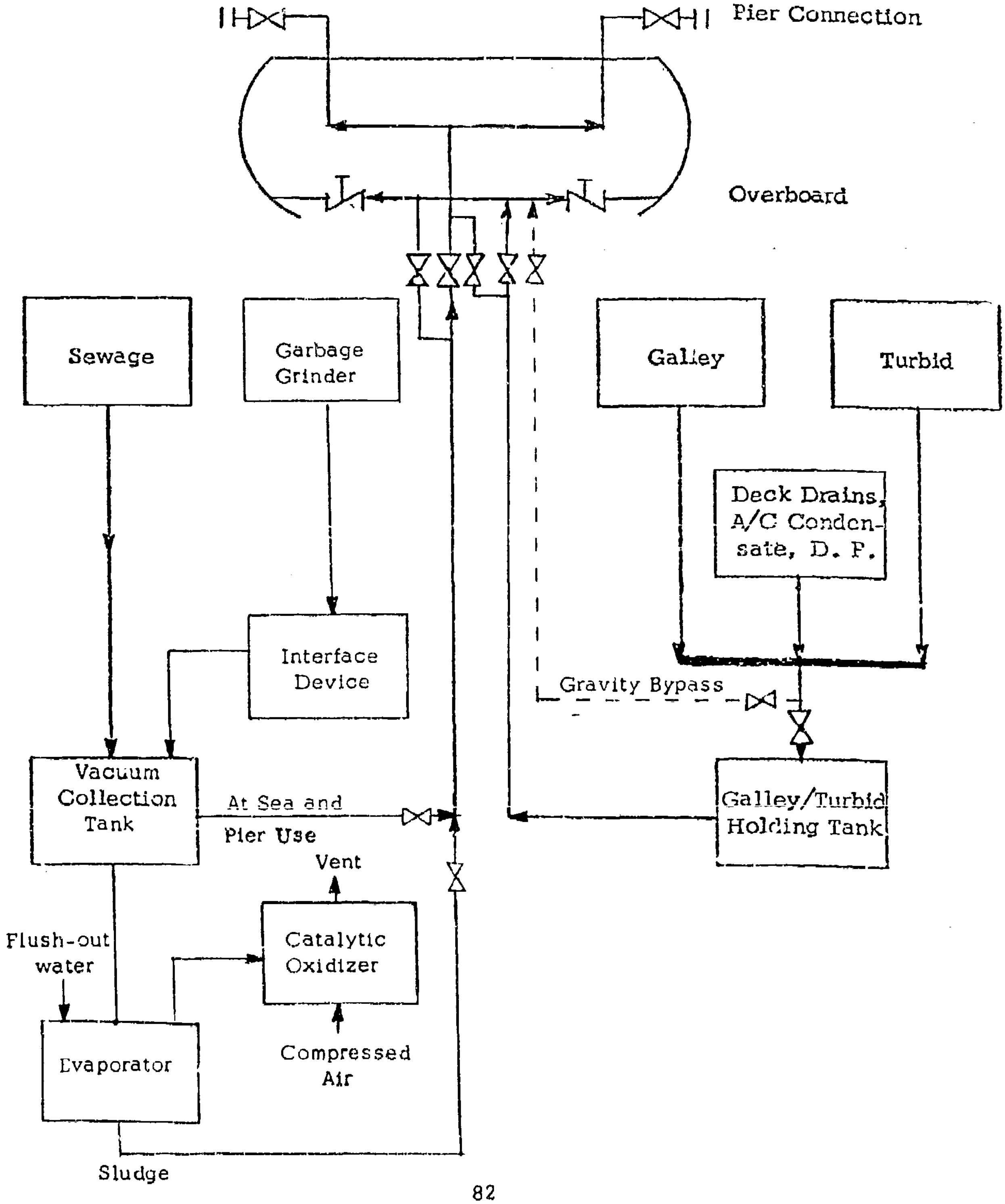
12. While the vessel is in unrestricted waters, all liquid wastes are discharged overboard. If the G/T drain manifold is above the waterline, provision can be made to bypass the holding tank. (The VCT cannot be bypassed.) If the vessel configuration will not allow gravity drainage overboard, G/T wastes drain to the holding tank from which it is be pumped overboard.

13. The incinerator is bypassed in unrestricted waters by pumping black water overboard from the VCT. When the vessel is tied up, both black and gray wastes are pumped to a pier connection. Since the VCT is small relative to the G/T holding tank, and the VCT cannot readily accept large volumes of gray water for off loading, each tank has its own riser to the pier connection manifold. Valving permits isolation of lines and independent discharge.

14. The gray water holding tank has a discharge pump plus a backup pump installed. Since the present pier connections accept a maximum of 30 gpm, discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based on a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inch. Nominal pump out time for the tank should be one hour if the resulting flow rate falls between these limits. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

15. The 250 gal VCT has a 7 gpm overboard discharge pump plus the backup provision of being able to blow the contents out with compressed air. The 60 and 120 gal VCT's use air pressurization as the primary evacuation mode and a branch off the recirculating macerator pump line as a backup.

11. JERED Reduced Volume Flush Vacuum Collection/GATX Evaporator for Concentrated Black Water/Holding Tank for Gray Water



1. This system collects sanitary wastes and garbage slurry from a garbage grinder via a vacuum sewerage system and evaporates it to a sludge for subsequent off loading. Black water volume is minimized by use of reduced flush, vacuum operated commodes.

2. Existing commodes are replaced by the special units that occupy the same nominal volume. Existing urinals are retained. The flush medium is changed from sea water to fresh water. Drain lines from the commodes are replaced by vacuum tight 1-1/2 inch lines. The flow in these lines can be horizontal, sloped upward at a few degrees or even up a vertical rise of less than six feet.

3. Urinals drain by gravity to an interface valve which can service up to five urinals. This valve, the urine discharge valve, is normally installed in the head space. It momentarily connects the vacuum, which is downstream of the valve, to the gravity filled line upstream of the valve. It is self-powered, float operated. When the liquid level rises sufficiently, the float opens an orifice to vacuum which pulls the urine through. After the liquid level drops, the float reseals the orifice.

4. An interface device is required for getting the ground garbage into the vacuum line. Options for the device are (1) a gray water valve which is similar to the urine discharge valve, (2) vented tank, (3) open drum. The latter two drain through a manual or remotely operated valve. Assuming no more than 40% of the daily ground garbage flow being generated at one mealtime, the tank or drum volume (including 20% extra for safety margin) would be sized at 0.72 gal per capita.

5. Two general styles of vacuum collection equipment have been produced and are available from JERED Industries. The small boat style is oriented towards private cabin cruisers, yachts and charter fishing boats. The equipment tends to be lighter, smaller, and less durable. Smaller components are usually not designed for maintenance; defective parts are replaced rather than repaired. Where the operational requirements are not severe, the equipment can provide more than adequate service. Tank sizes available are 30, 60, 120 and 200 gallons with liquid capacities of 20, 50, 100 and 167 gallons, respectively. All sizes are normally provided with one Gast 0822 vacuum pump (oil lubricated, sliding vane). With a duplicate vacuum pump in parallel, all systems are adequate for continual use by a crew of 16. By substituting Gast 1022 vacuum pumps, system capacity can be increased to 21 men. Pump models are almost identical except for motor rating. Manual valving will permit the vacuum pump to pressurize the tank and blow out the contents. However, evacuation of boiled-down sludge from the evaporator would be enhanced if the incoming solids were previously chopped. Therefore, evacuation of the small boat tanks will be performed by a macerating/transfer pump. Although the small boat systems are normally installed with flexible hose between components, the fittings will permit rigid piping.

6. The other style of vacuum collection equipment has been used for naval ships and similar heavy usage applications. The equipment tends to be heavier, stronger, more complex and designed for maintenance accessibility. Only one size will be required for the three larger vessels in this study: the V85003, installed singly on the USS Kraus and in duplicate on the USS Spruance. The 250-gallon VCT, holding approximately 200 gallons is furnished with water ring seal vacuum pumps, capable of continuous service for 200 men. Since System 11 utilizes evaporators instead of an incinerator, the collected sewage need not be finely ground nor be pumped out at a

controlled rate. Therefore, the 5 HP recirculating grinder pump and the incinerator feed pump are both replaced by a 1 1/2 HP macerating transfer pump. This results in a savings of almost 300 lbs and 4 HP hook-up load.

7. Vacuum collection equipment selected for the study vessels are given in Table 42. The 250-gal VCT assembly is as modified above.

Table 42

VCT SELECTIONS

Vessel		Manning	Longest Holding Time Required (Hrs)	Black Water Flow (gpd)	VCT	
					Size (gal)	Vacuum Pumps
Gallatin	(378')	152	97.5	513	250	WRS
Vigorous	(210')	60	172.0	203	250	WRS
Firebush	(180')	50	277.9	169	250	WRS
White Sage	(133')	21	65.5	71	30	1022
Pamlico (Under Constr.)	(160')	13	501.0*	44	30	0822
Point Herron	(82')	8	99.0	27	30	0822

WRS = Water Ring Seal type, included in VCT assembly.

*Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

8. The GATX evaporator is available in several sizes: 20, 40, 60 and 80-gallon capacity with working capacities of 16.25, 32.5, 48.75 and 65 gallons, respectively. Two ratings are important for an evaporator. One is the boiled-down sludge capacity in terms of man-days before the evaporator has to be emptied. With fresh water as the flushing medium, the four evaporator sizes will hold sludge volumes equivalent to 267, 534, 801 and 1068 man-days, respectively.

9. The other important value is the boil off rate. The evaporator must be capable of boiling off the water as fast as it comes in, except for the incremental residual sludge. Based upon the data for the

present design 80-gallon evaporator, the boil off rates for the four sizes, in terms of people accommodated, are: 6, 12.5, 19 and 25 men. However, by increasing the wattage of the electrical heaters, the accommodation equivalents can be increased. Based on empirical data for the 80-gallon evaporator, the four evaporators will accommodate 17.5, 35, 52.5 and 70 men.

10. The number and size of evaporators required for the six vessels are shown in Table 43. As seen in the table, the boil off rate is the determining factor for selection. The greater volume will permit extended periods between evaporator pump outs. A nominal over-capacity allows for possible degradation in boil off rate as the residual sludge level approaches maximum. Where the overcapacity may be excessive (White Sage and Point Herron), a decrease in wattage from the maximum rate will bring it into a reasonable range.

Table 43

EVAPORATOR SELECTIONS

Vessel		Manning	Longest Holding Time Required (Hrs)	Selection (By Basis)							Pump Out Frequency (days)	Longest Mission (days)
				Residual Volume			Boil Off At High Rate					
				No.	Gal	Days	No.	Gal	Equivalent Men	Over-Capacity %		
Gallatin	(378')	152	97.5	2	80	7.0	6	80	210	38	21	4.1
Vigorous	(210')	60	172.0	1	80	8.9	3	60	79	31	20	7.2
Firebush	(180')	50	277.9	1	80	10.7	2	80	70	40	21	11.6
White Sage	(133')	21	65.5	1	20	6.4	1	80	35	67	25	2.7
Pamlico (Under Constr.)	(160')	13	501.0*	1	40	20.5	1	40	17.5	35	20	20.9
Point Herron	(82')	8	99.0	1	20	16.7	1	40	17.5	119	33	4.1

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer time requirements.

For reference, the longest stay in restricted waters according to mission profile data is shown. The minimum evaporator volumes needed to meet mission requirements are determined as follows.

Sludge accumulates at the rate of 0.061 gpcd when using fresh water for flushing according to the GATX manual. Residual sludge from the garbage grinder slurry is assumed to be approximately equal to the sanitary sludge. Since sludge will accumulate twice as rapidly, the man-days of storage (from paragraph 9) are halved. Boil-off rate equivalents (from paragraph 10) are halved because the per capita flow rate is approximately doubled when garbage slurry is added.

11. Special consideration must be given to multiple evaporator installations. Transferring collected sanitary wastes and garbage slurry from the VCT to multiple evaporators can be done with one pump dedicated to each evaporator or with a single pump (plus standby) and sequencing valves and controls. In the latter case, when the VCT switch calls for evacuation, the pump fills an evaporator until the evaporator level switch causes valve shifting and the next evaporator in sequence starts to fill. A catalytic oxidizer is required for the vapor leaving an evaporator. An oxidizer with its associated heater, thermometers, compressed air supply and vent line, can service each evaporator or one large oxidizer set up can service all of them.

12. Physical characteristics of system components are given in Table 44. Vessel resource requirements are given in Table 45 and pipe connections or sizes are given in Table 46.

13. A gray water holding tank receives galley and turbid wastewater from drain lines that remain separate until reaching the holding tank. The maximum tank volumes required to hold all gray water generated during the longest stay in restricted waters, according to recorded mission profile data, is given in Table 47. They include additional volume equal to 20% of maximum liquid volume as safety margin.

Table 44

COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight (lbs)		Volume	Dimensions (inches)		
	Dry	Filled	cu ft	Height	Length	Width
Commode	30	31	3.1	16.3	20.3	16
Urine Dischg. Valve	7	8	0.2	12.4	-	5.6 dia
Vac. Collect. Tank †						
30 gal	57	223	4.4	-	38	16 dia
Vacuum Pump						
0822	43	-	1.0	18	10	10
1022	47	-	1.1	19	10	10
M/T Pump	125	127	1.0	10	25	7
Vac. Coll. Tank Assy.						
250 gal	4710	6610	165	66	72	60
Evaporator						
20 gal	300*	433*	13.2	43	-	26 dia
40 gal	470*	743*	20	43	-	32 dia
60 gal	620*	1025*	27.1	46	-	36 dia
80 gal	750	1375*	32.8	50	-	38 dia
Sludge Pump	35	35	0.3	7 dia	15	-
Catalytic Oxidizer (Uninsulated)	90	-	0.3	18	-	6 dia
Controls	75	-	3.1	21	12	21

† Includes tank and auxiliary components except for vacuum and M/T pumps.

* Estimated. Dry tank weight taken as 2/3 power of ratio to 80-gal tank. Water weight proportionately based on 65 gals in 30-gal tank plus 10 gals in steam jacket.

Table 45

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Compressed Air SCFM	Flush Water
Vacuum Pump*								
0822	1/2		120/240	1	60			
1022	3/4		120/240	1	60			
Vacuum Collect. Tank Assy.								
Vacuum Pump*	3		440	3	60			
Controls		250 est.	120	1	60			
M/T Pump	1 1/2		440	3	60			
Evaporator (Std)								30 psig
20 gal		1,373	440	3	60			
40 gal		2,745	440	3	60			
60 gal		4,118	440	3	60			
80 gal		5,490	440	3	60			
Evaporator (H gh Rate)								30 psig
20 gal		3,843	4 0	3	60			
40 gal		7,686	440	3	60			
60 gal		11,529	440	3	60			
80 gal		15,372	440	3	60			
Sludge Pump	1 1/2		440	3	60			
Vapor Treatment System								
20 gal std. evap.		325	440	1	60		2.5	
hi rate evap.		910	440	1	60		7.0	
40 gal std. evap.		650	440	1	60		5.0	
hi rate evap.		1,820	440	1	60		14.0	
60 gal std. evap.		975	440	1	60		7.5	
hi rate evap.		2,730	440	1	60		21.0	
80 gal std. evap.		1,300	440	1	60		10.0	
hi rate evap.		3,640	440	1	60		28.0	
Evaporator Controls		200 est.	440	1	60			

* Dual vacuum pumps frequently run at the same time.

Table 46

COMPONENT PIPE CONNECTION OR SIZE

Commode	Outlet Pipe: Water Supply:	1 1/2-inch IPS 1/2-inch ID Hose
Urinal Discharge Valve	Inlet & Outlet:	1 1/2-inch IPS
Vacuum Tanks		
30 gal	Inlet & Outlet: Vacuum Connection	2-inch NPT
250 gal	See JERED Dwg. H20118C001 (3 sheets)	
Vacuum Pump		
0822 and 1022	Inlet & Outlet:	3/8-inch IPS
Macerator/Transfer Pump	Inlet: Outlet:	3-inch NPT 1 1/4-inch NPT
Evaporator		
Waste Inlet (and sludge suction)	1 1/4-inch NPT	
Vapor Outlet	1 1/2-inch NPT	
Sludge Pump (in and out)	1 1/4-inch NPT	
Vapor Treatment System (80-gal evap.)		
Vapor (in and out)	1 1/4-inch NPT	
Compressed Air	1/4-inch NPT	

14. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. The evaporators will be bypassed by pumping overboard collected black water f om the VCT. Sludge in the evaporators can also be pumped overboard. If the G/T drain manifold is above the waterline, a gravity bypass drain line will be installed to conduct wastewater to the overboard scuppers. If a gravity bypass is not feasible, gray water will be pumped overboard from the G/T holding tank.

Table 47

MAXIMUM GRAY WATER HOLDING TANK VOLUMES

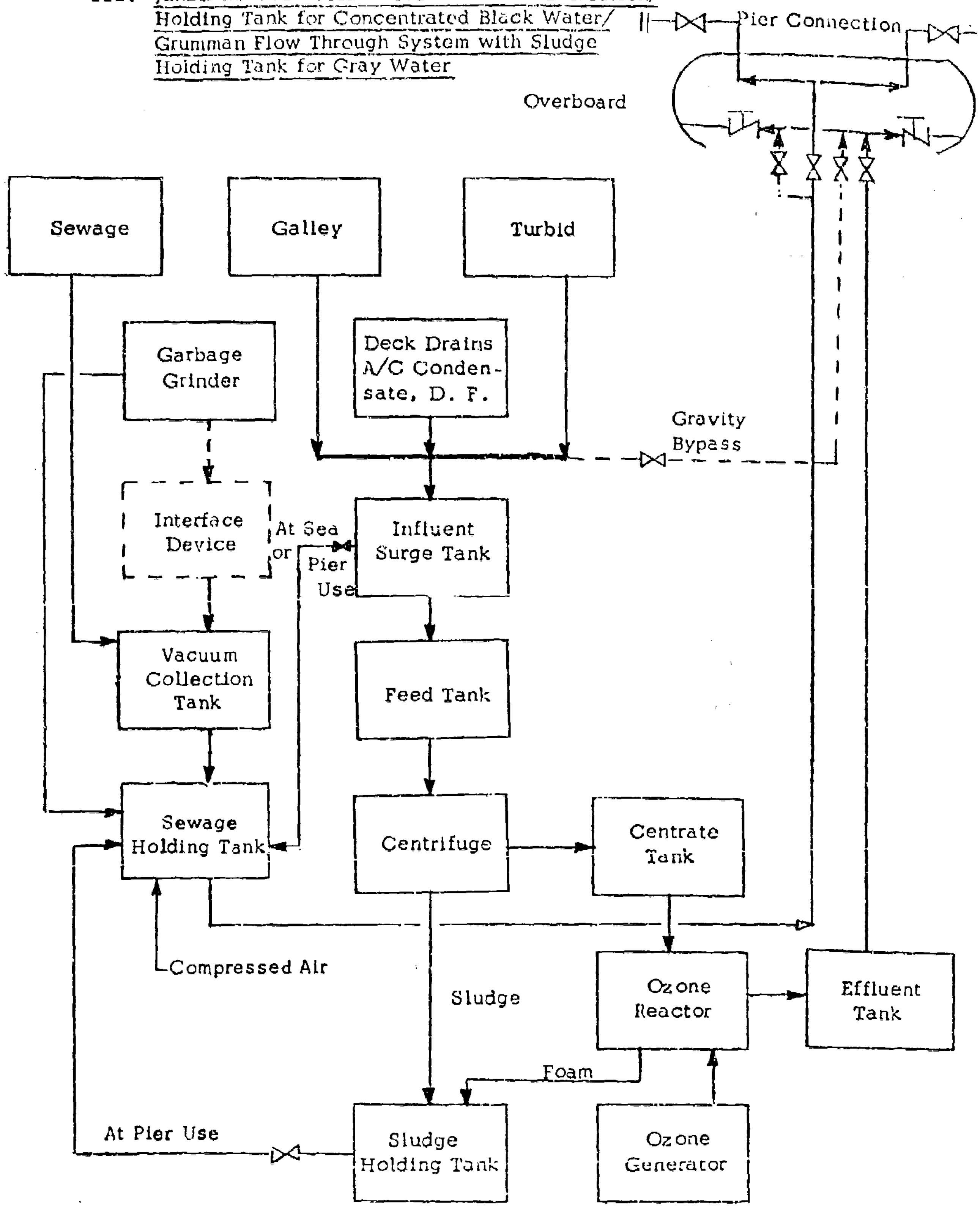
Vessel		Manning	Longest Hold. Time Required (Hrs)	gal	cu ft	Discharge Pump gpm
Gallatin	(378')	152	97.5	22,230	2,972	30
Vigorous	(210')	60	172.0	15,480	2,069	30
Firebush	(180')	50	277.9	20,843	2,786	30
White Sage	(133')	21	65.5	2,063	276	30
Pamlico (new construction)	(160')	13	501.0*	9,770	1,306	30
Point Herron	(82')	8	99.0	1,188	159	17

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

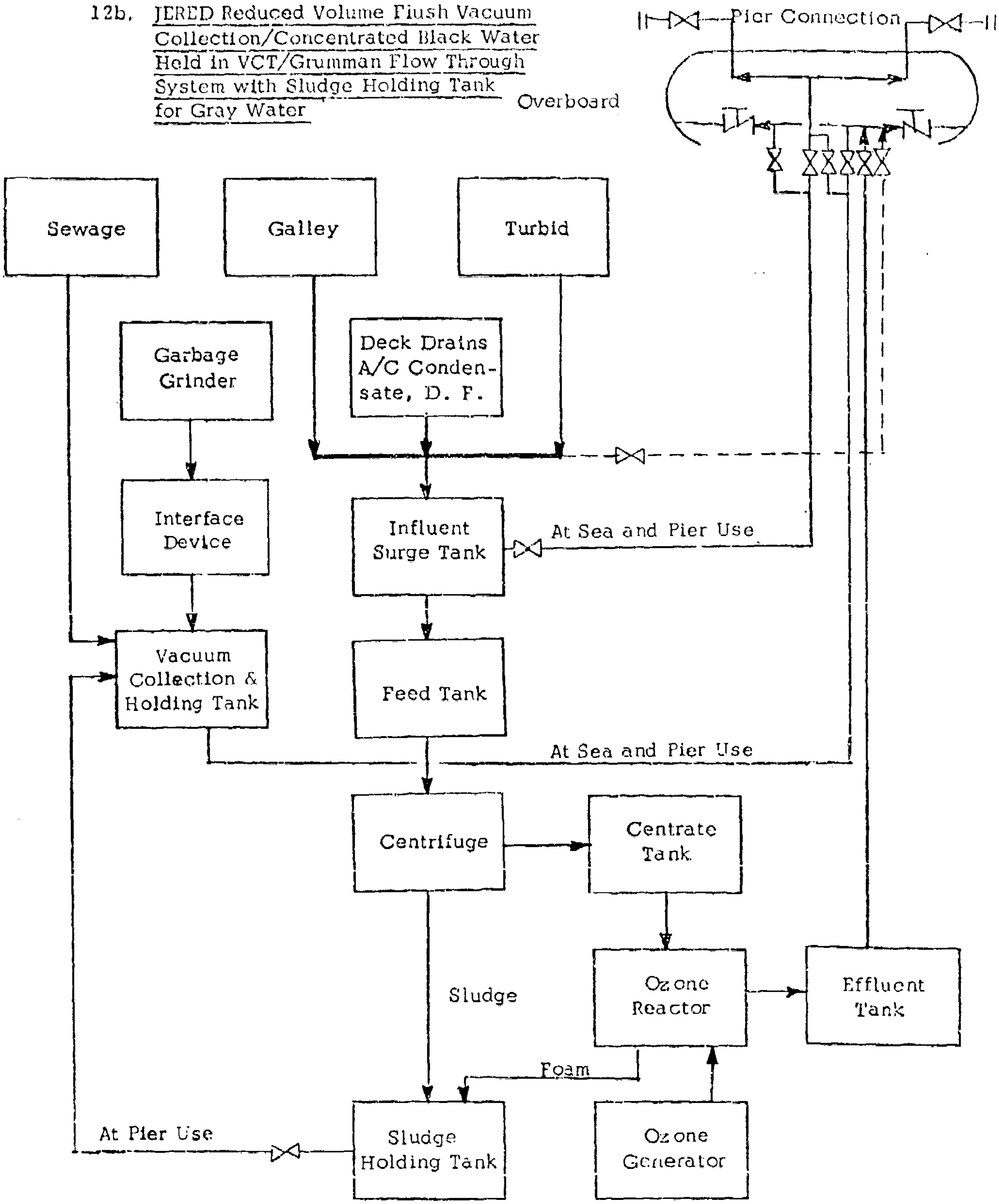
15. Because it is impractical to have the large quantities of gray water pulled into the VCT for off loading, the VCT and the gray water holding tank each have a riser to the overboard manifold. Separate risers will also permit overboard discharge of gray water in restricted zones where the G/T holding tank does not have as much holding time as the evaporators.

16. The VCT, evaporator(s) and G/T holding tank all are connected by valves and piping to the pier connection manifold. Pumps for the 250 gallon VCT and the evaporators are included in the WMS specifications. The 30 gallon VCT is emptied by air pressurization to either an evaporator or the pier connection. A backup mode of evacuation is discharge from the recirculation line of the macerator pump. The G/T holding tank has a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, the discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inches. Nominal pump out time for the G/T holding tank should be one hour if the resulting flow rate falls between these limits.

12a. JERED Reduced Volume Flush Vacuum Collection/ Holding Tank for Concentrated Black Water/ Grumman Flow Through System with Sludge Holding Tank for Gray Water



12b. JERED Reduced Volume Flush Vacuum Collection/Concentrated Black Water Held in VCT/Grumman Flow Through System with Sludge Holding Tank for Gray Water



1. This system provides flow through treatment of gray wastewater with holding of sanitary wastes, ground garbage slurry and gray water sludge. The system is a modification of the Grumman WMS, developed for the Coast Guard, tested on the CGC Red Beech, and described in the Grumman Operation and Maintenance Instructions. In addition to internal changes in the Grumman treatment system, the method of collecting sanitary wastes is different. The major components deleted are: the influent screen, disk centrifuge and the Grumman incinerator. The major components added are: an influent surge tank, surge tank pump, sludge holding tank and a sludge transfer pump.

2. Collection of sanitary wastes is accomplished by means of vacuum collection subsystem. Black water volume is minimized by use of reduced flush, vacuum operated commodes. They replace the existing commodes and occupy the same nominal volume. Existing urinals are retained. The flush medium is changed from sea water to fresh water. Drain lines from the commodes are replaced by vacuum tight 1-1/2 inch lines. The flow in these lines can be horizontal, sloped upward at a few degrees or even up a vertical rise of less than six feet.

3. Urinals drain by gravity to an interface valve which can service up to five urinals. This valve, the urine discharge valve, is normally installed in the head space. It momentarily connects the vacuum, which is downstream of the valve, to the gravity filled line upstream of the valve. It is self-powered, float operated. When the liquid level rises sufficiently, the float opens an orifice to vacuum which pulls the urine through. After the liquid level drops, the float reseals the orifice.

4. On vessels that have a sewage holding tank separate from the VCT, garbage grinder slurry can drain by gravity to the holding tank or be picked up by the VCT for subsequent transfer to the holding tank. The choice will be affected by the relative locations of the garbage grinder and the sewage holding tank. An interface device is required for getting the ground garbage into the vacuum line. Options for the

device are (1) an automatic gray water valve which is similar to the urine discharge valve, (2) vented tank, (3) open drum. The latter two drain through a manual or remotely operated valve. Assuming no more than 40% of the daily ground garbage flow being generated at one mealtime the tank or drum volume (including 20% extra for safety margin) would be sized at 0.72 gal per capita.

5. Two general styles of vacuum collection equipment have been produced and are available from JERED Industries. The small boat style is oriented towards private cabin cruisers, yachts and charter fishing boats. The equipment tends to be lighter, smaller, and less durable. Smaller components are usually not designed for maintenance; defective parts are replaced rather than repaired. Where the operational requirements are not severe, the equipment can provide more than adequate service. Tank sizes available are 30, 60, 120 and 200 gallons with liquid capacities of 20, 50, 100 and 167 gallons, respectively. All sizes are normally provided with one Gast 0822 vacuum pump (oil lubricated, sliding vane). With a duplicate vacuum pump in parallel, all systems are adequate for continual use by a crew of 16. By substituting Gast 1022 vacuum pumps, system capacity can be increased to 21 men. Pump models are almost identical except for motor rating. Manual valving permits the pump to pressurize the vacuum tank to blow out the contents. Although the small boat systems are normally installed with flexible hose between components, the fittings will permit rigid piping.

6. The other style of vacuum collection equipment has been used for naval ships and similar heavy usage applications. The equipment tends to be heavier, stronger, more complex and designed for maintenance accessibility. Only one size will be required for the three larger vessels in this study: the V85003, installed singly on the USS Kraus and in duplicate on the USS Spruance. The 250-gallon VCT, holding approximately 200 gallons, is furnished with water ring seal vacuum pumps, capable of continuous service for 200 men. The pump that normally feeds an incinerator directly will transfer collected black water to the incinerator feed tank. Since this system does not

incinerate collected sewage (and garbage slurry), the 5 HP Maz-O-Rator pump (270 lbs) is eliminated from the VCT package. The incinerator feed pump is used to transfer sewage to the holding tank.

7. Selections for black water collection plus holding tanks and one optional combined collection/holding tank for the Point Herron are given in Table 48. The maximum storage volumes (total of VCT and holding tank) are based on assumed flow rates and the longest stay in restricted waters, according to mission profile data. They provide additional volumes equal to 20% of maximum liquid volume as safety margin in the storage tank or as vacuum reservoir in the VCT. Option (b) for the Point Herron is reflected in diagram 12b. The problems associated with pulling a vacuum in a storage tank and aerating the contents are minimal in a small tank. They are partially offset by the problems of aerating a small vented tank.

Table 48

MAXIMUM VOLUMES OF BLACK WATER TANKS

Vessel		Man-ning	Longest Holding Time Required (Hrs)	Option	VCT		Holding Tank			
					Size gal	Vacuum Pumps	Maximum Volume		Discharge Pump gpm	Compressed Air SCFM
							gal	cu ft		
Gallatin	(378')	152	97.5	a	250	WRS	2300	307	30	31
Vigorous	(210')	60	172.0	a	250	WRS	1540	206	24	21
Firebush	(180')	50	277.9	a	250	WRS	2145	287	30	29
White Sage	(133')	21	65.5	a	30	1022	200	27	10	2.7
Pamlico (Under Constr.)	(160')	13	501.0*	a	30	0822	1070	143	15	15
Point Herron	(82')	8	90.0	a	30	0822	105	13.9	10	1.4
				b	200	0822	-	-	-	-

WRS = water ring seal type, included in VCT assembly.

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements

8. In a vented holding tank used for sewage, aeration is required to prevent septic, odor generating conditions. Compressed air is supplied by the vessels low pressure system. The flow rates, given in Table 48 for the maximum volume tank are based on 16.3 SCFM of air per 1000 gal of liquid. Pressure should nominally be 23 ft water column greater than

the maximum depth of the holding tank. If tank size is less than maximum, air flow rate is reduced proportionately. Aeration is not required for a vacuum collection/storage tank since generated odors are removed by the vacuum pumps.

9. The flow through system is designed for a steady influent rate of one gpm. Only one size (or capacity) system is currently available. Table 49 presents the number of systems required for each vessel to treat gray water only, the hours of operation of each system, the expected volume of sludge per day and the maximum tank volume to retain the sludge generated during the longest stay in restricted waters, according to recorded mission profile data. The tank volumes include an additional 20% of the maximum liquid volume as safety margin.

Table 49
SYSTEM OPERATION AND VOLUME OF TANKS

Vessel		Crew Size	Longest Holding Time Required (Hrs)	Total Flow gpd	No. of System	System Operation hr/day (each)	Sludge gpd	Sludge Holding Tank		Influent Surge Tank	
								gal	cu ft	gal	cu ft
Gallatin	(378')	152	97.5	4560	4	19.0	380	1853	248	2335	312
Vigorous	(210')	60	172.0	1800	2	15.0	150	1290	172	922	123
Firebush	(180')	50	277.9	1500	2	12.5	125	1737	232	768	103
White Sage	(133')	21	65.5	630	1	10.5	53	172	23	323	43
Pamlico (New Construction)	(160')	13	501.0*	390	1	6.5	32	814	109	200	27
Point Herron	(82')	8	99.0	240	1	4.0	20	99	13	123	16

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

10. Galley and turbid wastes are collected by gravity drains (separate from each other and the sanitary vacuum lines) which lead to one or more influent surge tank(s) for batch transfer to the treatement system feed tank. The total volume of the surge tank(s), including additional volume equal to 20% of the liquid as safety margin, is given in Table 49. The volumes were calculated as half the daytime flow figuring that 80% of the turbid water and all of the galley water is collected during the day. Each flow-through treatment system will have its own surge tank pump, whether the number of tanks is equal

to or less than the number of systems. The pump(s) should be located with the tank(s) but they need not be located near or on the same level as the treatment systems.

11. Located within the bounds of the Grumman system framework are the original 30-gallon feed tank, metering feed pump, basket centrifuge, centrate tank, centrate pump, ozone generator, ozone reactor, effluent tank and effluent pump. The sludge holding tank must be located near the ozone reactor but need not be within the Grumman System framework. It could be located on a deck below, provided the foam and centrifuge sludge can drain into it by gravity.

12. A design option for the sewage holding tank and the sludge holding tank is to have both functions accommodated in a combined holding tank except for Option (b) for the Point Herron. This option uses a consolidated vacuum collection and holding tank. Storage and off loading for both tanks are normally done at the same time. The combined function tank is 84% larger than the sewage holding tank. Compressed air flow would also be increased by 84%. If these functions remain separate, the sludge holding tank will be provided with a gravity drained or pumped connection to the sewage holding tank for use during off loading.

13. During the system operation, the effluent pump periodically discharges a nominal 7 gpm at 20 psig from the 10-gallon effluent tank. The effluent is piped to a riser leading to the overboard discharge manifold. Where multiple WMS's are involved, they discharge to a common riser.

14. Physical characteristics of the modified Grumman main structure and other components are presented in Table 50. Resource requirements are given in Table 51 and pipe connections or sizes are given in Table 52.

Table 50

COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight (lbs)		Volume	Dimensions (inches)		
	Dry	Filled	cu ft	Height	Length	Width
Commode	30	31	3.1	16.3	20.3	16.0
Urine Dischg. Valve	7	8	0.2	12.4	-	5.6 dia
Vac. Collect. Tank						
30 gal	57	223	4.4	-	38.0	16.0dia
200 gal	542	1927	33.5	-	72.0	[illegible]2.0dia
Vacuum Pump						
0822	43	-	1.0	18.0	10.0	10.0
1022	47	-	1.1	19.0	10.0	10.0
M/T Pump	125	127	1.0	10.0	25.0	7.0
Vac. Coll. Tank Assy.						
250 gal	5000	6900	165.0	66.0	72.0	60.0
Main Structure		3056	236.0	85.0	63.0	76.0

Table 51

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air SCFM	Cooling Water gpm
Vacuum Pump*								
0822	1/2		120/240	1	60			
1022	3/4		120/240		60			
Vac. Coll. Tank Assy.	3		440	3	60			
Vacuum Pump*	3		440	3	60			
Overboard Pump	3		440	3	60			
Effluent Pump	1/2		440	3	60			
Controls		250 est.	120	1	60			
Surge Tank Pump	1/2		440	3	60			
Basket Centrifuge	2		208	3	60			
Scoop Motor		115	120	1	60			
Ozone Generator		2100	120/208	3	60		2	1
Effluent Pump	1/3		115	1	60			
Centrate Pump	1/8		115	1	60			1/4
Sludge Pump	1/4		120	3	60			
Controls (GAC)		est. 200	120	1	60			

* Dual vacuum pumps frequently run at the same time.

Table 52

COMPONENT PIPE CONNECTION OR SIZE

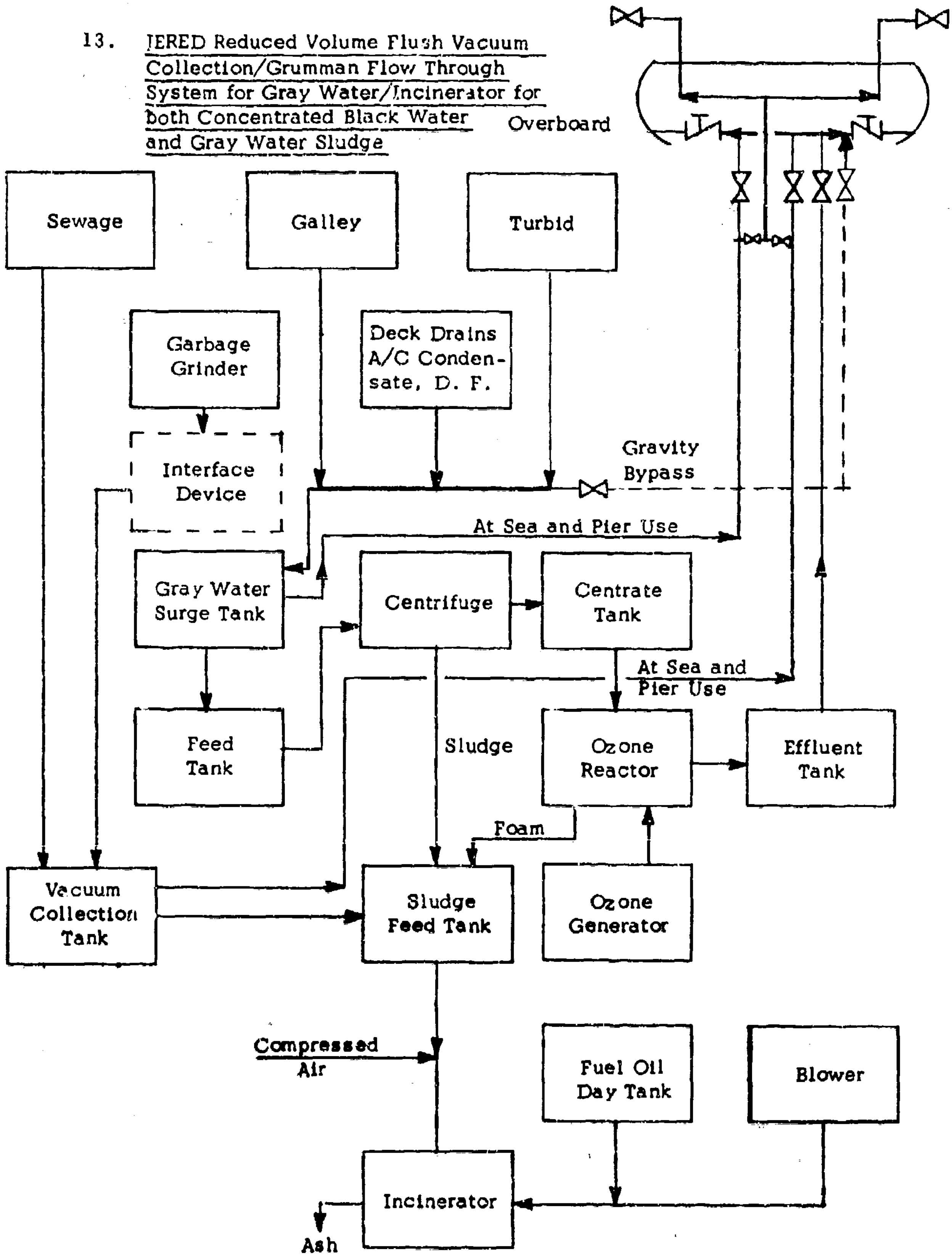
Commode	Outlet Pipe:	1 1/2-inch IPS
	Water Supply:	1/2-inch ID Hose
Urinal Discharge Valve	Inlet & Outlet:	1 1/2-inch IPS
Vacuum Tanks		
30 gal	Inlet & Outlet:	2-inch NPT
200 gal	Vacuum Connection	
250 gal	See JERED Dwg. H20118C001 (3 sheets)	
Vacuum Pump		
0822 and 1022	Inlet & Outlet:	3/8-inch IPS
Macerator/Transfer Pump	Inlet:	2-inch NPT
	Outlet:	1 1/4-inch NPT

From	To	Size (inches)	
Sources	Gray Water Surge Tank	Existing	
Influent Surge Tank Pump	Basket Centrifuge	1/2	IPS
Effluent Pump	Riser	3/4-1	IPS

15. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. In order to simplify riser piping and overboard pumping operations, all wastes being collected or previously collected are pumped from the sewage holding tank (or the optional combined holding tank). For use in off loading, the G/T influent surge tank is provided with a gravity drained or pumped transfer line to the sewage holding tank as in diagram 12a, or pumped directly off the vessel as in diagram 12b.

16. The sewage holding tank (or combined holding tank) will have a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up to a minimum sized pipe riser of 1-1/2 inches. Discharge pump flow rates are given in Table 48. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

13. IERED Reduced Volume Flush Vacuum Collection/Grumman Flow Through System for Gray Water/Incinerator for both Concentrated Black Water and Gray Water Sludge



1. This system provides flow-through treatment of gray wastewater with incineration of sanitary wastes, ground garbage slurry and gray water sludge. The system is a modification of the Grumman WMS, developed for the Coast Guard, tested on the CGC Red Beech, and described in the Grumman Operation and Maintenance Instructions. In addition to internal changes in the treatment system, the method of collecting sanitary wastes is different. The point of insertion of black water into the system is also changed. The major components deleted are: the influent screen, disk centrifuge and the Grumman incinerator. The major components added are: an influent surge tank, surge tank pump and a Thiokol incinerator subsystem. The subsystem is comprised of: an incinerator, sludge feed tank, sludge pump, high pressure blower, fuel oil day tank and pump.

2. Collection of sanitary wastes is accomplished by means of vacuum collection subsystem. Black water volume is minimized by use of reduced flush, vacuum operated commodes. They replace the existing commodes and occupy the same nominal volume. Existing urinals are retained. The flush medium is changed from sea water to fresh water. Drain lines from the commodes are replaced by vacuum tight 1-1/2 inch lines. The flow in these lines can be horizontal, sloped upward at a few degrees or even up a vertical rise of less than six feet.

3. Urinals drain by gravity to an interface valve which can service up to five urinals. This valve, the urine discharge valve, is normally installed in the head space. It momentarily connects the vacuum, which is downstream of the valve, to the gravity filled line upstream of the valve. It is self-powered, float operated. When the liquid level rises sufficiently, the float opens an orifice to vacuum which pulls the urine through. After the liquid level drops, the float reseals the orifice.

4. An interface device is required for getting the ground garbage into the vacuum line. Options for the device are (1) a gray water valve which is similar to the urine discharge valve, (2) vented tank, (3) open drum. The latter two drain through a manual or remotely operated valve. Assuming no more than 40% of the daily ground garbage flow being generated at one mealtime, the tank or drum volume (including 20% extra for safety margin) would be sized at 0.72 gal per capita.

5. Two general styles of vacuum collection equipment have been produced and are vailable from JERED Industries. The small boat style is oriented towards private cabin cruisers, yachts and charter fishing boats. The equipment tends to be lighter, smaller, and less durable. Smaller components are usually not designed for maintenance; defective parts are replaced rather than repaired. Where the operational requirements are not severe, the equipment can provide more than adequate service. Tank sizes available are 30, 60, 120 and 200 gallons with liquid capacities of 20, 50, 100 and 167 gallons, respectively. All sizes are normally provided with one Gast 0822 vacuum pump (oil lubricated, sliding vane). With a duplicate vacuum pump in parallel, all systems are adequate for continual use by a crew of 16. By substituting Gast 1022 vacuum pumps, system capacity can be increased to 21 men. Pump models are almost identical except for motor rating. Manual valving permits the pump to pressurize the vacuum tank to blow out the contents. Added to the small boat VCT will be a recirculating macerator pump which will reduce particulate size to prevent incinerator nozzle clogging. It could optionally transfer sewage to the sludge tank in place of air pressurized blowing of the VCT. Although the small boat systems are normally installed with flexible hose between components, the fittings will permit rigid piping.

Table 54

SYSTEM OPERATION AND GRAY WATER SURGE TANK VOLUME

Vessel		Manning	Longest Holding Time Required (Hrs)	Gray Water Flow gpd	No. of Systems	System Operation hr/day (each)	Sludge gpd	Total Incin. Feed gpd	No. of Incin.	Incin. Operation hr/day (average)	Gray Water Surge Tank	
											gal	cu ft
Gallatin	(378')	152	97.5	4560	4	19.0	380	893	8	18.6	2335	312
Vigorous	(210')	60	172.0	1800	2	15.0	150	353	3	19.6	922	123
Firebush	(180')	50	277.9	1500	1	24.0*	125	294	3	16.3	768	103
White Sage	(133')	21	65.5	630	1	10.5	53	123	1	20.5	323	43
Pamlico (under constr.)	(160')	13	501.0**	390	1	6.5	33	76	1	12.7	200	27
Point Herron	(82')	8	99.0	240	1	4.0	20	47	1	7.8	123	16

* **Requires 4% increase in flow rate.**

** Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

9. Galley and turbid wastes are collected by gravity drains (separate from each other and the sanitary vacuum lines) which lead to one or more influent surge tank(s) for batch transfer to the treatment system feed tank. The total volume of the surge tank(s), including additional volume equal to 20% of the liquid as safety margin, is given in Table 54. The volumes were calculated as half the daytime flow figuring that 80% of the turbid water and all of the galley water is collected during the day. Each flow-through treatment system will have its own surge tank pump, whether the number of tanks is equal to or less than the number of systems. The pump(s) should be located with the tank(s) but they need not be located near or on the same level as the treatment systems.

10. Located within the bounds of the Grumman system framework are the original 30 gallon feed tank, metering feed pump, basket centrifuge, centrate tank, centrate pump, ozone generator, ozone reactor effluent tank and effluent pump. New equipment, entirely within the framework, are the sludge feed tank, sludge pump and incinerator blower. The incinerator is mostly within the confines of the Grumman structure and the shelf presently holding the disk centrifuge. The burner projects beyond the shelf. The incinerator control panel is mounted externally

to the framework. A preliminary Thiokol arrangement sketch shows the location of the new incineration equipment modifying the Grumman design.

11. A Thiokol flow diagram of the incineration subsystem depicts the relationship of the added components. This diagram is modified by a revised sludge flow schematic, substituting continuous sludge recirculation for bubble aeration in the sludge feed tank. The drawings give interconnecting line sizes. Thiokol drawing 7U45700 gives the cross section of an IR & D Incinerator with a bill of materials. It is modified by the substitution of a high pressure Hauck burner as shown on the Outline Drawing of the Sludge Incinerator. Drawing 7U47822 gives dimensions and details of the Sludge Tank Assembly.

12. As shown in Table 54, the three larger vessels require more incinerators than flow through systems. The extra incinerators will each have a sludge feed tank, blower and fuel oil pump. The number and location of fuel oil day tanks would be determined by incinerator locations. On the Gallatin, distribution of vacuum collected sewage will be to the four incinerators that are not associated with flow through systems. The independent incinerators on the Gallatin will operate 21.4 hr/day and the built in units only 15.8 hr/day. Redundant VCT effluent pumps and diverting valves will allow sequential filling of the independent sludge feed tanks. On the Vigorous and Firebush, the VCT will discharge to all three incinerator feed tanks by means of one effluent pump dedicated to each incinerator subsystem.

13. The flow through system effluent pump periodically discharges a nominal 7 gpm at 20 psig from the 10-gallon effluent tank. The effluent is piped to a riser leading to the overboard discharge manifold. Where multiple systems are involved, they all discharge to one common riser.

14. Physical characteristics of the modified Grumman main structure and other components are presented in Table 55. Resource requirements are given in Table 56 and pipe connections or sizes are given in Table 57.

Table 55

COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight (lbs)		Volume	Dimensions (inches)		
	Dry	Filled	cu ft	Height	Length	Width
Commode	30	31	3.1	16.3	20	16 dia
Urine Dischg. Valve	7	8	0.2	12.4	-	5.6 dia
Vac. Collect. Tank*						
30 gal	57	223	4.4	-	38	16 dia
Vacuum Pump						
0822	43	-	1.0	18	10	10
1022	47	-	1.1	19	10	10
M/T Pump**	125	127	1.0	10	25	7
Vac. Coll. Tank Assy.						
250 gal	5000	6900	165	66	72	60
Main Structure		4380	236	85	63+	76‡
Incinerator	800	-	23.8	40	49	21
Blower	260	-	11.0	24	36	22
Sludge Tank	50	220	6.5	31	30	12
Control Box	125	-	3.5	30	20	10
Fuel Oil Day Tank						
Gallatin		Δ 1778	38.1			
Vigorous		Δ 702	15.0			
Firebush		Δ 585	12.5			
White Sage		Δ 246	5.3			
Pamlico		Δ 152	3.3			
Point Herron		Δ 94	2.0			

* Includes tank and auxiliary components except for vacuum pump(s)

** Included in 250 gal VCT Assembly.

Δ = Weight of oil.

\+ Plus 10 inches for control panel, 20 in W x 30 H

‡ Plus projection of incinerator nozzle.

Table 56

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air SCFM	Compressed Air SCFM	Fuel Oil gph	Cooling Water gpm
Vacuum Pump*										
0822	1/2		120/240	1	60					
1022	3/4		120/240		60					
Vac. Collect. Assy.	3		440	3	60					
Vacuum Pump*	3		440	3	60					
Overboard Pump	3		440	3	60					
Effluent Pump	1/2		440	3	60					
Controls		250 est.	120	1	60					
M/T Pump	1-1/2		440	3	60					
Surge Tank Pump	1/2		440	3	60					
Basket Centrifuge	2		208	3	60					
Scoop Motor		115	120	1	60					
Ozone Generator		2100	120/208	3	60		2			1
Effluent Pump	1/3		115	1	60					
Centrate Pump	1/8		115	1	60					1/4
Blower	2		208	3	60					
		Opt.	460							
Incinerator			208	3	60		100	12	1-1/2	
		Opt.	460	3	60					
Fuel Oil Pump	est. 1/4		120	1	60					
Sludge Pump	1/4		120	1	60					
Controls (GAC)		est. 200	120	1	60					
Controls (Thiokol)		est. 200	120	1	60					

* Dual vacuum pumps frequently run at the same time.

** For use with VCT on smaller vessels.

Table 57

COMPONENT PIPE CONNECTION OR SIZE

Commode	Outlet Pipe: 1 1/2-inch IPS Water Supply: 1/2-inch ID Hose
Urinal Discharge Valve	Inlet & Outlet: 1 1/2-inch IPS
Vacuum Tanks	
30 gal	Inlet & Outlet: 2-inch NPT Vacuum Connection
250 gal	See JERED Dwg. H20118C001 (3 sheets)
Vacuum Pump	
0822 and 1022	Inlet & Outlet: 3/8-inch IPS
Macerator/Transfer Pump	Inlet: 2-inch NPT Outlet: 1 1/4-inch NPT
Incinerator	
Blower Connection	2 1/2-inch NPT
Sludge Connection	1/2-inch NPT
Compressed Air	1/2-inch NPT
Sludge Tank Inlet	1-inch flange
Outlet	1-inch flange
Blower	2 1/2-inch NPT

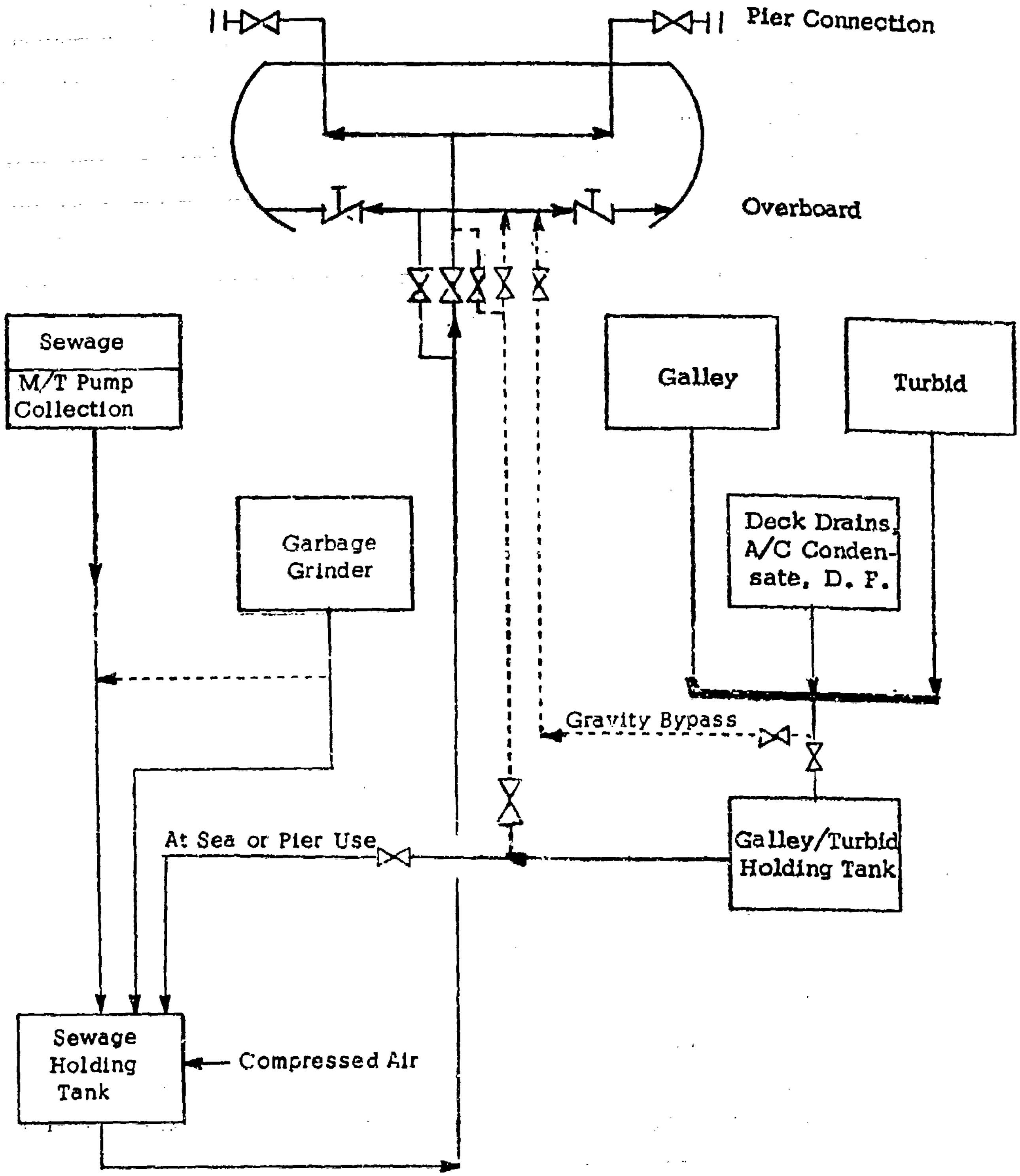
From	To	Size (inches)	
Sources	Gray Water Surge Tank	Existing	
Influent Surge Tank Pump	Basket Centrifuge	1/2	IPS
Fuel Oil Pump	Incinerator	1/4	IPS
Effluent Pump	Riser	3/4-1	IPS
Incinerator	Atmosphere	7 1/2 ID x 14 OD* Insulated Stack	

* Stack may vary in size depending upon installation.

15. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. The system is bypassed by pumping from the black and gray surge tanks. Because of the disparate sizes and the impracticality of passing large quantities of gray water through the vacuum tank, each surge tank will have a riser to the overboard manifold.

16. Each surge tank will have a discharge pump with the tank's transfer pump serving as a backup. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum flow for gray water discharge pumps is 10 gpm based on a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inches. Nominal pump out time should be one hour if the resulting flow rate falls between these limits. Since the black water has passed through a macerator, smaller pumps and smaller risers will be acceptable for black water surge tank off loading. Nominal pump out time should range from 30 to 60 minutes.

14. GATX Reduced Volume Flush M/T Pump Collection/Holding Tank for Concentrated Black Water/Holding Tank for Gray Water



1. This system provides no waste treatment but retains all wastes in holding tanks for subsequent off loading. It is similar to System 9 except that the reduced flush commodes and sewage transport method are different. Existing commodes are replaced by GATX shock mounted, single flush-pedal units with cable actuation of the flushometer valves. The urinals are standard. Both fixtures drain by gravity into the suction line of a macerator/transfer (M/T) pump mounted below the deck. An M/T pump can accommodate up to three commodes and the urinals commonly associated with them. The suction line to the pump should be short (up to eight feet to the farthest commode).

2. The commode flush mechanism incorporates a switch which actuates the M/T pump for each flush. If the piping arrangement will not permit urinal wastewater to drain through the pump while it is not operating, then a counting mechanism will actuate the M/T pump after a nominal number (five) of urinal flushes. Flushing medium will be fresh water instead of sea water. The sewer lines from the M/T pumps to the holding tank are changed to smaller diameter pressure pipes. Since they operate as filled lines, sloping is not necessary.

3. The line from the garbage grinder to the sewage holding tank can be gravity drained, separate from all other drain lines or it can be a pressurized line joining the M/T pump discharge line leading to the holding tank. Pressure would be generated by a solids handling pump. The choice will be a function of relative locations of the garbage grinder and the holding tank.

4. The maximum volumes of black water holding tanks required to hold all black water that is generated during the longest stay in restricted waters, according to recorded mission profile data, are given in Table 58. They all include additional volume equal to 20% of maximum liquid volume as safety margin.

Table 58

MAXIMUM HOLDING TANK VOLUMES

Vessel		Manning	Longest Holding Time Required (Hrs)	Sanitary				Galley and Turbid		
				gal	cu ft	Compressed Air SCFM	Discharge Pump gpm	gal	cu ft	Discharge Pump gpm
Gallatin	(378')	162	975.5	2501	334	34	30	22,230	2972	30
Vigorous	(210')	60	172.0	1742	233	24	24	15,480	2069	30
Firebush	(180')	50	277.9	2345	313	32	30	20,843	2786	30
White Sage	(133')	21	65.5	232	31	3.2	10	2,063	276	10
Pamlico (Under Constr.)	(160')	13	501.0*	1099	147	15	15	9,770	1306	30
Point Herron	(82')	8	99.0	134	13	1.8	10	1,188	159	10

*Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

5. The sanitary holding tank is aerated to prevent septic, odor generating conditions. Compressed air is supplied by the vessel's low pressure system. The flow rates, given in Table 58 for the maximum volume tank, are based on 16.3 SCFM of air per 1000 gal of liquid. Pressure should nominally be 23 ft water column greater than the maximum depth of the holding tank. If tank size is less than maximum, air flow rate rate is reduced proportionately.

6. A gray water holding tank receives galley and turbid wastewater from drain lines that remain separate until reaching the holding tank. The maximum tank volumes required to hold all gray water generated during the longest stay in restricted waters, according to recorded mission profile data is given in Table 58. They include additional volume equal to 20% of maximum liquid volume as safety margin.

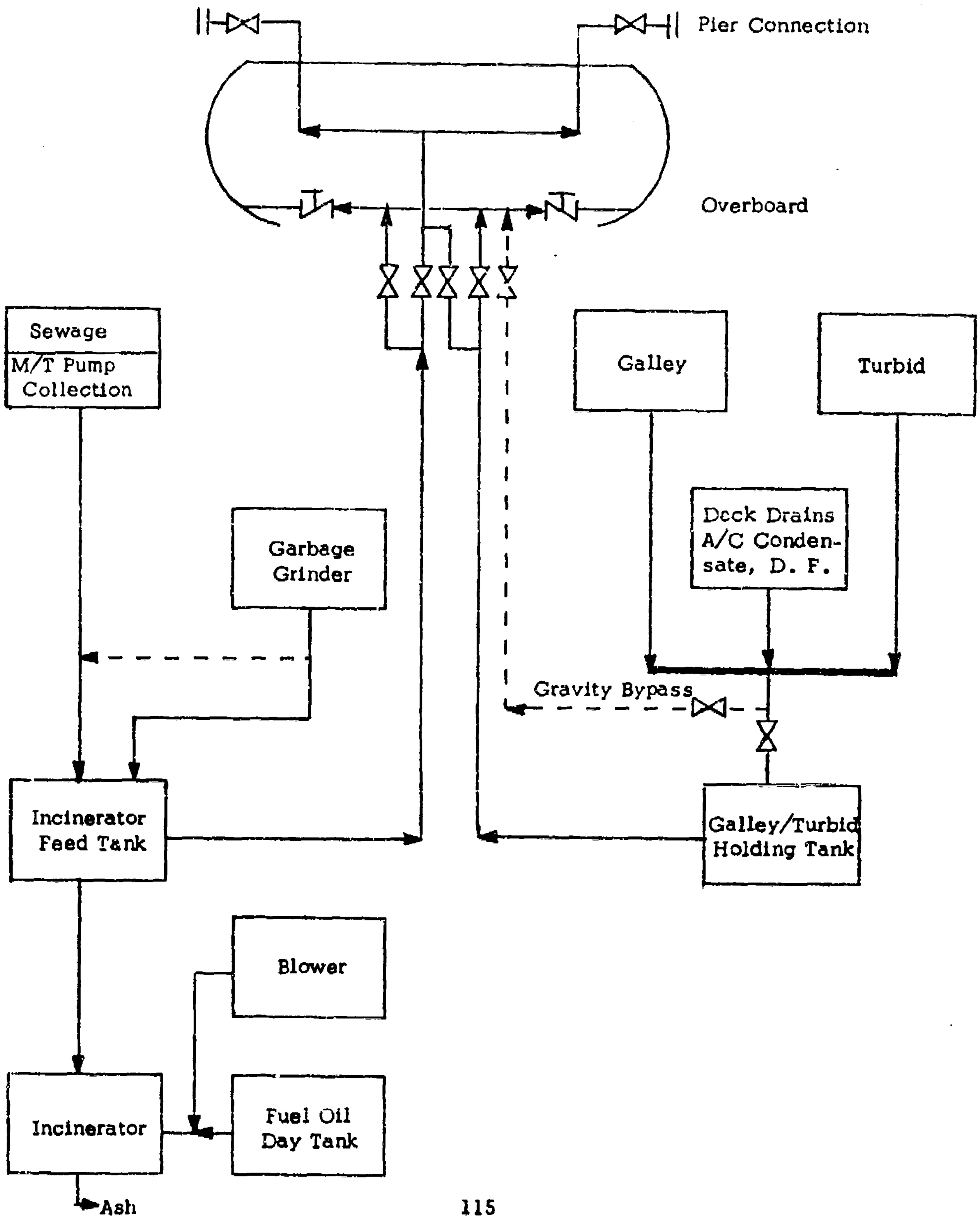
7. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. If the G/T drain manifold is above the water-line, a gravity bypass drain line will be installed to conduct waste-water to the overboard scuppers. If a gravity bypass is not feasible, gray water will be pumped from the G/T holding tank to the sewage

holding tank and then pumped overboard. This latter arrangement is also used for off loading collected wastes to a pier connection.

8. For the situation where the G/T holding tank does not match the sewage holding tank in terms of retention time, and a gravity bypass is not feasible, a separate riser is installed between the tank discharge line and the overboard manifold. This permits dumping excess gray water in restricted zones when the tank is full.

9. Each holding tank will have a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inches. Nominal pump out time for each tank should be one hour if the resulting flow rate falls between these limits. However, because of the relatively small volumes of the sewage holding tanks on the three smaller vessels and the transfer sequence for off loading, the discharge pumping rate for the gray water tanks should be reduced to that of the sewage discharge pumping rate.

15. GATX Reduced Volume Flush M/T Pump Collection/Incinerator for Concentrated Black Water/Holding Tank for Gray Water



1. This system collects sanitary wastes by means of small diameter pressure sewers. Reduced flush commodes help minimize the sewage volume injected into the sewers by macerating/transfer (M/T) pumps. Black water (including garbage slurry) is incinerated and the gray water is stored for subsequent off loading.

2. Existing commodes are replaced by GATX shock mounted, single flush-pedal units with cable actuation of the flushometer valves. The urinals are standard. Both fixtures drain by gravity into the suction line of an M/T pump mounted below the deck. An M/T pump can accommodate up to three commodes and the urinals commonly associated with them. The suction line to the pump should be short (up to eight feet to the farthest commode).

3. The commode flush mechanism incorporates a switch which actuates the M/T pump for each flush. If the piping arrangement will not permit urinal wastewater to drain through the pump while it is not operating, then a counting mechanism will actuate the M/T pump after a nominal number (five) of urinal flushes. Flushing medium will be fresh water instead of sea water. The sewer lines from the M/T pumps to the holding tank are changed to smaller diameter pressure pipes. Since they operate as filled lines, sloping is not necessary.

4. The line from the garbage grinder to the incinerator feed tank can be gravity drained, separate from all other drain lines or it can be a pressurized line joining the M/T pump discharge line leading to the feed tank (or evaporator). Pressure is provided by a solids handling pump. The choice will be a function of relative locations of the garbage grinder and the feed tank.

5. Only one size of JERED incinerator is currently available. It is rated to burn 30 gph of slurry with a maximum of 4% solids. The percentage of solids in the feed is expected to range from 2 1/2 to 3%. A combustion air blower is provided in the skid-mounted incinerator assembly. Only one size of Thiokol incinerator subsystem is currently available, rated to burn 6 gph of sewage sludge. This subsystem was originally designed for use with another WMS installed on the CGC Red Beech. It is comprised of the incinerator, high pressure blower (for combustion air), recirculating sludge pump, oil day tank and pump, and electrical control box.

6. A Thiokol flow diagram of the incineration subsystem depicts the relationship of the components. This diagram is modified by a revised sludge flow schematic, substituting continuous sludge recirculation for bubble aeration in the sludge feed tank. The drawings given interconnecting line sizes. Thiokol drawing 7U45700 gives the cross section of an IR & D Incinerator with a bill of materials. It is modified by the substitution of a high pressure Hauck burner as shown on the Outline Drawing of the Sludge Incinerator. Drawing 7U47822 gives dimensions and details of the Sludge Tank Assembly. The peripheral equipment should be located in the general vicinity but not necessarily adjoining the incinerator.

7. Incinerator selection and daily burn time is given for each vessel in Table 59. The incinerator feed tank is used to equalize the flow to the incinerator and to dampen out surges. For the three larger vessels which employ the Jered incinerator, the feed tank is sized to hold half the daily flow plus 20% additional volume as safety margin. The three smaller vessels employ the Thiokol incinerator subsystem but with resized feed tanks (called sludge tanks by Thiokol). The feed tank on the White Sage holds the full daily flow plus 33% additional volume as safety margin. The feed tanks for the Pamlico and Point Herron will hold two days' flow (plus safety margin) for incinerator operation every other day. This is thermally more efficient and helps prolong the life of the incinerator.

Tank volumes are also given in Table 59. The incinerator feed pump is located with the feed tank but they need not be located near or on the same level as the incinerator.

Table 59

FEED TANK SIZE AND INCINERATOR BURN TIME

Vessel		Manning	Longest Holding Time Required (Hrs)	Black Water Flow gpd	Feed Tank Volume		Incineration Burn Time (hour/day)
					gal	cu ft	
Gallatin	(378')	162	97.5	513	300	40	17.1 J
Vigorous	(210')	60	172.0	203	125	17	6.8 J
Firebush	(180')	50	277.9	169	100	13	5.6 J
White Sage	(133')	21	65.5	71	50	6.7	11.8 T
Pamlico (Under Constr.)	(160')	13	501.0**	44	50	6.7	14.7* T
Point Herron	(82')	8	99.0	27	50	6.7	9.0* T

* J = JERED T = THIOKOL Every other day.

** Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

8. Physical characteristics, resource requirements and pipe connections or sizes for the system components are given in Tables 60, 61 and 62, respectively.

Table 60
COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight (lbs)		Volume	Dimensions (inches)		
	Dry	Filled	(cu ft)	Height	Length	Width
Commode	80	81	3.5	19	21	15
M/T Pump	125	127	1.0	10	25	7
Incinerator Feed Pump (Jered)	144	147	2.5	16	30	9
Incinerator (Jered)	2,000	-	102	63	77	36
Incinerator (Thiokol)	800	-	23.8	40	49	21
Blower	260	-	11.0	24	36	22
Control Box	125	-	3.5	31	20	10
Fuel Oil Day Tank						
Gallatin		△ 960	20.7			
Vigorous		△ 382	8.2			
Firebush		△ 315	6.7			
White Sage		△ 140	3.0			
Pamlico		△ 177	3.8			
Point Herron		△ 107	2.3			

△ = Weight of oil

Table 61
WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air SCFM	Compressed Air SCFM	Fuel Oil gph
M/T Pump	1 1/2		440	3	60				
Incinerator (Jered)			440	3	60	10 max			
			110	1	60	1.0		15	
Feed Pump	1/2		440	3	60				
Blower	5		440	3	60		2,700*		
Oil Pump	1/3		440	3	60				7.5 est
Controls		250 est	110	1	60				
Incinerator (Thiokol)			208	3	60				
		Opt	460	3	60				
Blower	2		208	3	60		100	12	1.6
		Opt	460	3	60				
Oil Pump	est 1/4		120	1	60				
Feed Pump	1/4		120	1	60				
Controls		est. 200							

* Combustion blower withdraws 720 SCFM. Compartment ventilation required is 2700 SCFM (per incinerator).

Table 62

COMPONENT PIPE SIZE CONNECTIONS

Macerator/Transfer Pump:	Inlet: 3-inch NPT Outlet: 1 1/4-inch NPT
Incinerator (JERED)	
Sludge Connection	1/2-inch NPT
Compressed Air	1/4-inch NPT
Stack	8-inch 150-lb steel flange*
Incinerator (Thiokol)	
Blower Connection	2-1/2 inch NPT
Sludge Connection	1/2 inch NPT
Compressed Air	1/2 inch NPT
Stack	7-1/2 inch ID x 14 OD insulated stack*

*Stack may vary in size depending upon installation.

9. A gray water holding tank receives galley and turbid wastewater from drain lines that remain separate until reaching the holding tank. The maximum tank volumes required to hold all gray water generated during the longest stay in restricted waters, according to recorded mission profile data is given in Table 63. They include additional volume equal to 20% of maximum liquid volume as safety margin.

Table 63

MAXIMUM GRAY WATER HOLDING TANK VOLUMES

Vessel		Manning	Longest Hold. Time Required (Hrs)	gal	cu ft	Discharge Pump gpm
Gallatin	(378')	152	97.5	22,230	2,972	30
Vigorous	(210')	60	172.0	15,480	2,069	30
Firebush	(180')	50	277.9	20,843	2,786	30
White Sage	(133')	21	65.5	2,063	276	30
Pamlico (new construction)	(160')	13	501.0*	9,770	1,306	30
Point Herron	(82')	8	99.0	1,188	159	17

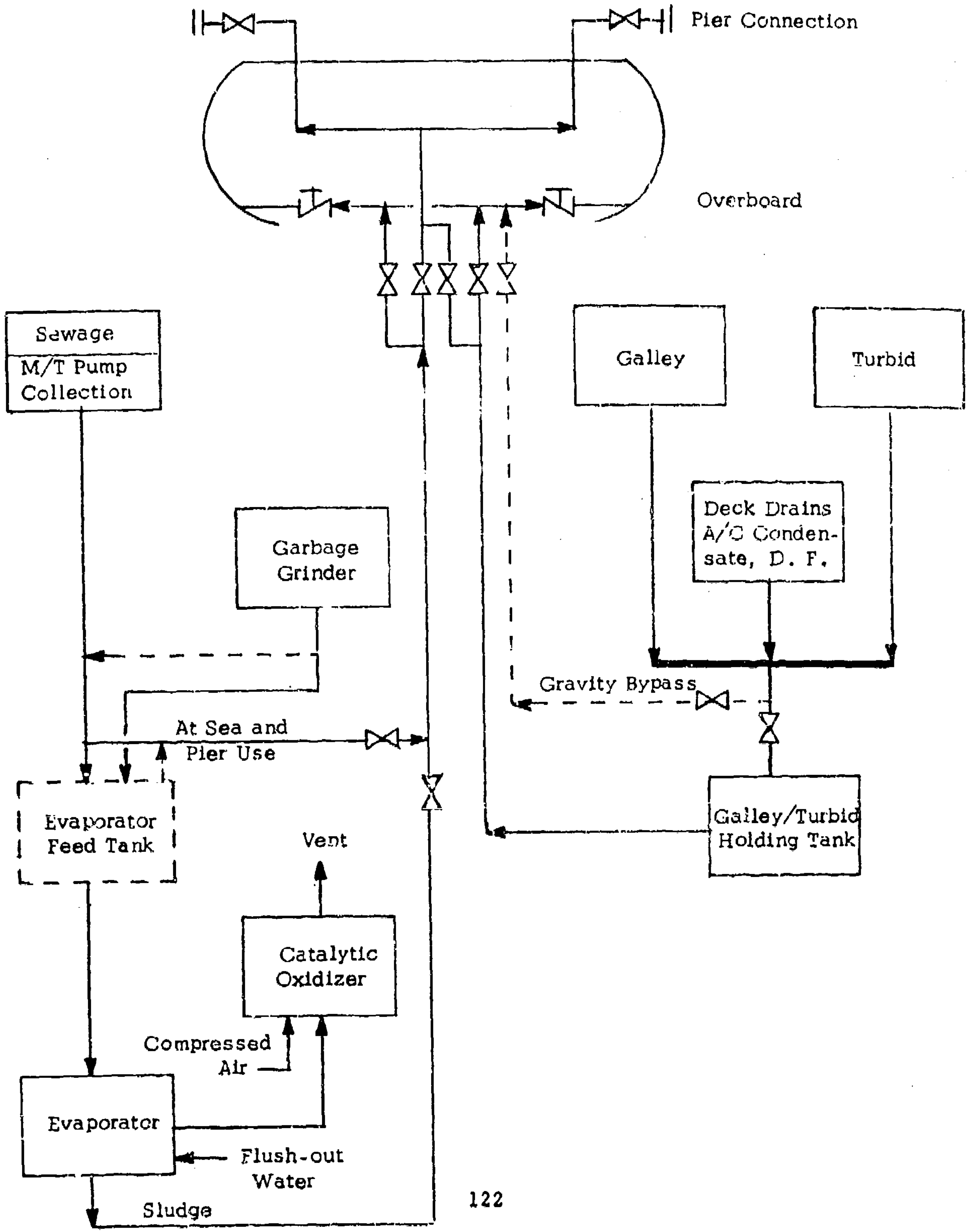
* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

10. While the vessel is in unrestricted waters, all liquid waters are discharged overboard. If the G/T drain manifold is above the water-line, provision can be made to bypass the holding tank. (The incinerator feed tank cannot be bypassed.) If the vessel configuration will not allow gravity drainage overboard, G/T wastes drain to the holding tank from which it is pumped overboard.

11. The incinerator is bypassed in unrestricted waters by pumping black water overboard from the incinerator feed tank. When the vessel is tied up, both black and gray wastes are pumped to a pier connection. Since the feed tank is small relative to the G/T holding tank and cannot readily accept large volumes of gray water for off loading, each tank has its own riser to the pier connection manifold. Valving permits isolation of lines and independent discharge.

12. The gray water holding tank has a discharge pump plus a backup pump installed. The incinerator feed tank has a single overboard discharge pump with the incinerator feed pump as a backup. Since the present pier connections accept a maximum of 30 gpm, discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inch. Nominal pump out time for the tank should be one hour if the resulting flow rate falls between these limits. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

16. <u>GATX Reduced Volume Flush M/T Pump Collection/GATX Evaporator for Concentrated Black Water/Holding Tank for Gray Water</u>



1. This system collects sanitary wastes by means of small diameter pressure sewers. Reduced flush commodes help minimize the sewage volume injected into the sewers by macerating/transfer (M/T) pumps. Black water (including garbage slurry) is evaporated to a sludge and the gray water is stored for subsequent off loading along with the black water sludge.

2. Existing commodes are replaced by GATX shock mounted, single flush-pedal units with cable actuation of the flushometer valves. The urinals are standard. Both fixtures drain by gravity into the suction line of an M/T pump mounted below the deck. An M/T pump can accommodate up to three commodes and the urinals commonly associated with them. The suction line to the pump should be short (up to eight feet to the farthest commode).

3. The commode flush mechanism incorporates a switch which actuates the M/T pump for each flush. If the piping arrangement will not permit urinal wastewater to drain through the pump while it is not operating, then a counting mechanism will actuate the M/T pump after a nominal number (five) of urinal flushes. Flushing medium will be fresh water instead of sea water. The sewer lines from the M/T pumps to the holding tank are changed to smaller diameter pressure pipes. Since they operate as filled lines, sloping is not necessary.

4. The line from the garbage grinder to the incinerator feed tank can be gravity drained, separate from all other drain lines or it can be a pressurized line joining the M/T pump discharge line leading to the feed tank (or evaporator). Pressure is provided by a solids handling pump. The choice will be a function of relative locations of the garbage grinder and the feed tank (or evaporator).

5. An evaporator feed tank may be used to properly distribute collected wastes to multiple evaporators. Multiple evaporators occur on the three larger vessels. The tank sizes, based on a half day's supply to the evaporators plus 20% additional as a safety margin, are 300, 125 and 100 gallons for the Gallatin, Vigorous and Firebush, respectively. An alternate possibility is the use of decentralized evaporators whereby the waste sources are allocated to specific evaporators. This would permit shorter pressurized drain lines, simpler controls and distribution and the elimination of the feed tank. On the three smaller vessels which have only one evaporator each, an evaporator feed tank is not required. The evaporator feed pump is located with the feed tank but they need not be located near or at the same level as the evaporators.

6. The GATX evaporator is available in several sizes: 20, 40, 60 and 80-gallon capacity with working capacities of 16.25, 32.5, 48.75 and 65 gallons, respectively. Two ratings are important for an evaporator. One is the boiled-down sludge capacity in terms of man-days before the evaporator has to be emptied. With fresh water as the flushing medium, the four evaporator sizes will hold sludge volumes equivalent to 267, 534, 801 and 1068 man-days, respectively.

7. The other important value is the boil off rate. The evaporator must be capable of boiling off the water as fast as it comes in, except for the incremental residual sludge. Based upon the data for the present design 80-gallon evaporator, the boil of rates for the four sizes, in terms of people accommodated, are: 6, 12.5, 19, and 25 men. However, by increasing the wattage of the electrical heaters, the accommodation equivalents can be increased. Based on empirical data for the 80-gallon evaporator, the four evaporators will accommodate 17.5, 35, 52.5 and 70 men.

8. The number and size of evaporators required for the six vessels are shown in Table 64. As seen in the table, the boil off rate is the determining factor for selection. The greater volume will permit extended periods between evaporator pump outs. A nominal over-capacity allows for possible degradation in boil off rate as the residual sludge level approaches maximum. Where the overcapacity may be excessive (White Sage and Point Herron), a decrease in wattage from the maximum rate will bring it into a reasonable range. For reference, the longest stay in restricted waters according to mission profile data is shown.

Table 64

EVAPORATOR SELECTIONS

Vessel	Man-ning	Longest Holding Time Required (Hrs)	Selection (By Basis)							Pump Out Frequency (days)	Longest Mission (days)
			Residual Volume			Boil Off At High Rate					
			No.	Gal	Days	No.	Gal	Equivalent Men	Overcapacity %		
Gallatin (378')	152	97.5	2	80	7.0	6	60	210	38	21	4.1
Vigorous (210')	60	172.0	1	80	8.9	3	60	79	31	20	7.2
Firebush (180')	50	277.9	1	80	16.7	2	80	70	40	21	11.6
White Sage (133')	21	65.5	1	20	6.4	1	80	35	67	25	2.7
Pamlico (160') (Under Constr.)	13	501.0*	1	40	20.5	1	40	17.5	35	29	20.9
Point Herron (82')	8	99.0	1	20	16.7	1	40	17.5	119	33	4.1

* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

9. The minimum evaporator volumes needed to meet mission requirements are determined as follows. Sludge accumulates at the rate of 0.061 gpcd when using fresh water for flushing according to the GATX manual. Residual sludge from the garbage grinder slurry is assumed to be approximately equal to the sanitary sludge. Since sludge will accumulate twice as rapidly, the man-days of storage (from paragraph 6) are halved. Boil-off rate requivalents (from paragraph 7) are halved because the per capita flow rate is approximately doubled when garbage slurry is added.

10. Special considerations must be given to multiple evaporator installations. Transferring collected sanitary wastes and garbage slurry from the evaporator feed tank to the evaporators can be done with one pump dedicated to each evaporator or with a single pump (plus standby), diverting valve(s) and controls. Since the vapor leaving an evaporator must pass through a catalytic oxidizer before venting above decks, one Vapor Treatment System, including oxidizer, heater, thermal switches, thermometer, compressed air supply and vent line, can service each evaporator or one large unit can service all of them.

11. Physical characteristics, resource requirements, and pipe connections for the system components are given in Tables 65, 66 and 67, respectively.

Table 65

COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight		Volume	Dimensions		
	Dry	Filled	cu ft	Height	Length	Width
Commode	80	81	3.5	19	21	15
M/T Pump	125	127	1.0	10	25	7
Evap. Feed Pump	144	147	2.5	16	30	9
Evaporator						
20 gal	300*	433*	13.2	43	-	26 dia
40 gal	470*	743*	20.0	43	-	32 dia
60 gal	620*	1025*	27.1	46	-	36 dia
80 gal	750	1375*	32.8	50	-	38 dia
Sludge Pump	35	35	0.3	7 dia	15	-
Catalytic Oxidizer (uninsulated)	90*	-	0.3	18	-	6 dia
Controls	75	-	3.1	21	12	21

* Estimated. Dry tank weight taken as 2/3 power of ratio to 80-gal tank. Water weight proportionately based on 65 gals in 80-gal tank plus 10 gals in steam jacket.

Table 66

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Compressed Air SCFM	Flush Water
M/T Pump	1 1/2		440	3	60			
Evaporator Feed Pump	1/2		440	3	60			
Evaporator (Std)								30 psig
20 gal		1,373	440	3	60			
40 gal		2,745	440	3	60			
60 gal		4,118	440	3	60			
80 gal		5,490	440	3	60			
Evaporator (High Rate)								30 psig
20 gal		3,843	440	3	60			
40 gal		7,686	440	3	60			
60 gal		11,529	440	3	60			
80 gal		15,372	440	3	60			
Sludge Pump	1 1/2		440	3	60			
Vapor Treatment System								
20 gal std. evap.		325	440	1	60		2.5	
hi rate evap.		910	440	1	60		7	
40 gal std. evap.		650	440	1	60		5	
hi rate evap.		1,820	440	1	60		14	
60 gal std. evap.		975	440	1	60		7.5	
hi rate evap.		2,730	440	1	60		21	
80 gal std. evap.		1,300	440	1	60		10	
hi rate evap.		3,640	440	1	60		28	
Controls		200 est.	440	1	60			

Table 67

COMPONENT PIPE CONNECTIONS

Macerator/Transfer Pump	Inlet:	3-inch NPT
	Outlet:	1 1/4-inch NPT
Evaporator Feed Pump	Vertical:	1 1/2-inch Flange (125#)
	Horizontal:	1 1/4-inch NPT (Flow in either direction)
Evaporator		
Waste Inlet (and sludge suction)	1 1/4-inch NPT	
Vapor Outlet	1 1/2-inch NPT	
Sludge Pump (in and out)	1 1/4-inch NPT	
Vapor Treatment System (80-gal evap.)		
Vapor (in and out)	1 1/4-inch NPT	
Compressed Air	1/4-inch NPT	

12. A gray water holding tank receives galley and turbid wastewater from drain lines that remain separate until reaching the holding tank. The maximum tank volumes required to hold all gray water generated during the longest stay in restricted waters, according to recorded mission profile data is given in Table 68. They include additional volume equal to 20% of maximum liquid volume as safety margin.

Table 68

MAXIMUM GRAY WATER HOLDING TANK VOLUMES

Vessel		Manning	Longest Hold Time Required (Hrs)	gal	cu ft	Discharge Pump gpm
Gallatin	(378')	152	97.5	22,230	2,972	30
Vigorous	(210')	60	172.0	15,480	2,069	30
Firebush	(180')	50	277.9	20,843	2,786	30
White Sage	(133')	21	65.5	2,063	276	30
Pamlico (new construction)	(160')	13	501.0*	9,770	1,306	30
Point Herron	(82')	8	99.0	1,188	159	17

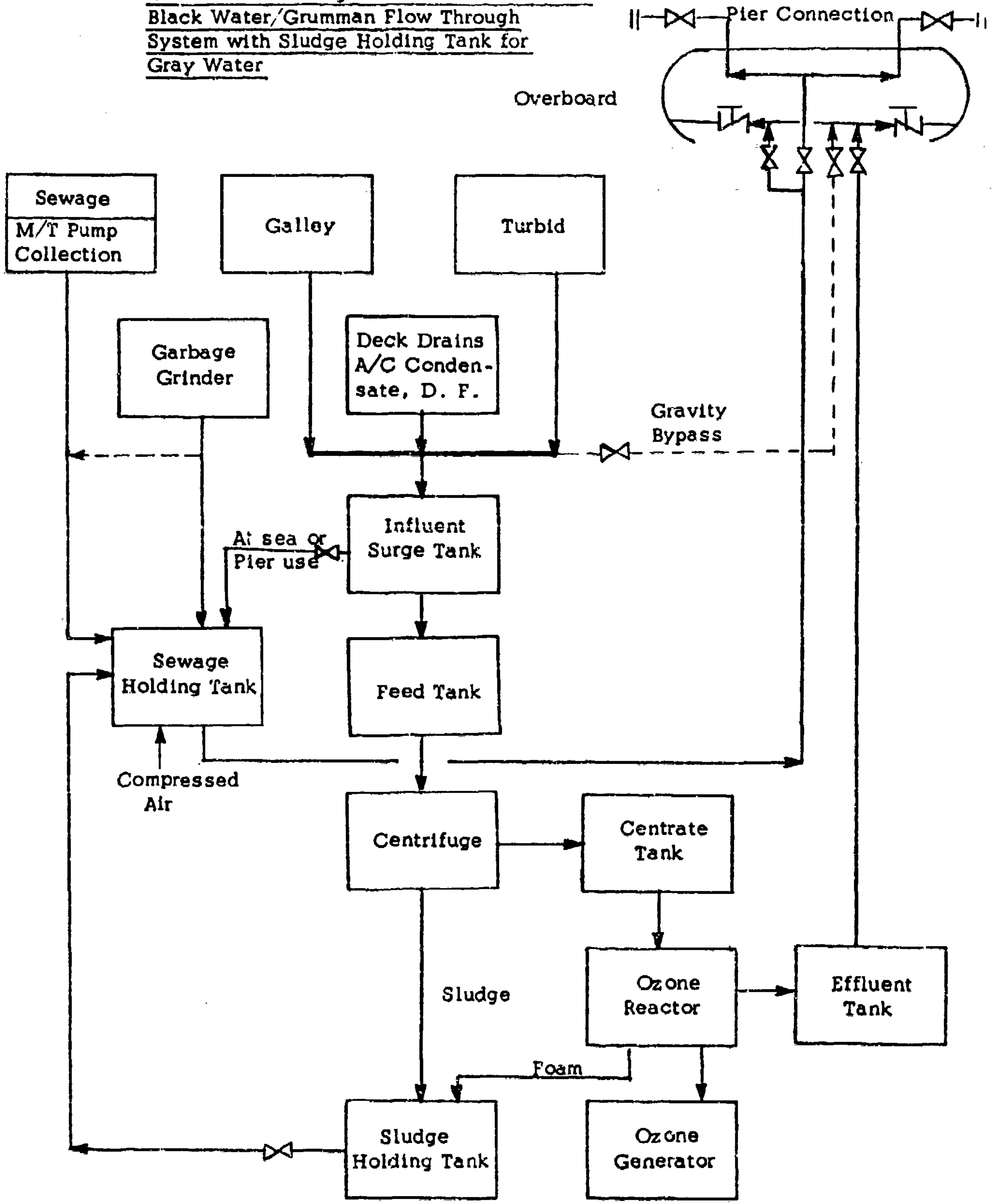
* Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

13. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. The evaporators will be bypassed by pumping directly overboard with the M/T pumps where there is no evaporator feed tank. With a feed tank, an overboard discharge pump evacuates wastewater as it is collected. The evaporator feed pump serves as a backup pump.

14. If the G/T drain manifold is above the waterline, a gravity bypass drain line will be installed to conduct wastewater to the overboard scuppers. If a gravity bypass is not feasible, gray water will be pumped overboard from the G/T holding tank, Because it is impractical to have the large quantities of gray water pumped through the feed tanks (or evaporators) for off loading, the feed tank and the gray water holding tank each have a riser to the overboard manifold. Separate risers will also permit overboard discharge of gray water in restricted zones where the G/T holding tank does not have as much holding time as the evaporators.

15. Discharge pumps for the feed tank, evaporator(s) and G/T holding tank are connected by valves and piping to the pier connection manifold. Each evaporator comes with its own sludge pump. The G/T holding tank has a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, the discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up a minimum sized pipe riser of 1-1/2 inches. Nominal pump out time for the G/T holding tank should be one hour if the resulting flow rate falls between these limits.

17. GATX Reduced Volume Flush M/T Pump Collection/Holding Tank for Concentrated Black Water/Grumman Flow Through System with Sludge Holding Tank for Gray Water



1. This system provides flow-through treatment of gray wastewater with holding of black water and gray water sludge. The system is a modification of the Grumman WMS, developed for the Coast Guard, tested on the CGC Red Beech, and described in the Grumman Operation and Maintenance Instructions. In addition to internal changes in the Grumman treatment system, the method of collecting sanitary wastes is different. For the Grumman treatment system, the major components deleted are: the influent screen, disk centrifuge and incinerator. The major components added are: an influent surge tank, surge tank pump, sludge holding tank and a sludge transfer pump.

2. Collection of sanitary wastes is accomplished by means of small diameter pressure sewers. Pressurization is provided by macerator/transfer (M/T) pumps. Since pressure sewers operate full, routing need not be sloped nor continuously descending. Gray water is collected by standard, gravity drained lines.

3. Reduced flush commodes minimize the sanitary sewage volume which is subsequently incinerated. Flushing medium will be fresh water instead of sea water. Existing commodes are replaced by GATX shock mounted, single flush-pedal units with cable actuation of the flushometer valves. They occupy approximately the same volume as standard units. The urinals are standard. Both fixtures drain by gravity into the suction line of an M/T pump mounted below the deck. An M/T pump can accommodate up to three commodes and the urinals commonly associated with them. The suction line to the pump should be short (up to eight feet to the farthest commode).

4. The commode flush mechanism incorporates a switch which actuates the M/T pump for each flush. If the piping arrangement will not permit urinal wastewater to drain through the pump while it is not operating, then a counting mechanism will actuate the M/T pump after a nominal number (five) of urinal flushes.

5. Sanitary sewage is collected and held in a storage tank for subsequent off loading to a pier connection or overboard in unrestricted waters. Slurry from the garbage grinder either drains by gravity to the holding tank or it is transferred by a solids handling pump through the pressurized sewer lines. The choice is a function of relative locations of the garbage grinder and the holding tank.

6. The maximum volumes of black water holding tanks required to hold all black water that is generated during the longest stay in restricted waters, according to recorded mission profile data, are given in Table 69. They all include additional volume equal to 20% of maximum liquid volume as safety margin.

Table 69

MAXIMUM HOLDING TANK VOLUMES

Vessel		Manning	Longest Hold. Time Required (Hrs)	Gal	Cu Ft	Compressed Air SCFM	Discharge Pump gpm
Gallatin	(378')	152	97.5	2501	334	34	30
Vigorous	(210')	60	172.0	1742	233	24	24
Firebush	(180')	50	277.9	2345	313	32	30
White Sage	(133')	21	65.5	232	31	3.2	10
Pamlico (under constr.)	(160')	13	501.0*	1099	147	15	15
Point Herron	(82')	8	99.0	132	18	1.8	10

*Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

7. The sanitary holding tank is aerated to prevent septic, odor generating conditions. Compressed air is supplied by the vessel's low pressure system. The flow rates, given in Table 69 for the maximum volume tank, are based on 16.3 SCFM of air per 1000 gal of liquid. Pressure should nominally be 23 ft water column greater than the maximum depth of the holding tank. If tank size is less than maximum, air flow rate is reduced proportionately.

8. The flow through system is designed for a steady influent rate of one gpm. Only one size (or capacity) system is currently available. Table 70 presents the number of systems required for each vessel to treat gray water only, the hours of operation of each system, the expected volume of sludge per day and the maximum tank volume to retain the sludge generated during the longest stay in restricted waters, according to recorded mission profile data. The tank volumes include an additional 20% of the maximum liquid volume as safety margin.

Table 70

FLOW THROUGH SYSTEM, OPERATION AND VOLUME OF TANKS

Vessel		Crew Size	Longest Holding Time Required (Hrs)	Total Flow gpd	No. of Systems	System Operation hr/day (each)	Sludge gpd	Sludge Holding Tank		Influent Surge Tank	
								gal	cu ft	gal	cu ft
Gallatin	(378')	152	97.5	4560	4	19.0	380	1853	248	2335	312
Vigorous	(210')	60	172.0	1800	2	15.0	150	1290	172	922	123
Firebush	(180')	50	277.9	1500	2	12.5	125	1737	232	768	103
White Sage	(133')	21	65.5	630	1	10.5	53	172	23	323	43
Pamlico (New Constr.)	(160')	13	501.0*	390	1	6.5	32	814	109	200	27
Point Herron	(82')	8	99.0	240	1	4.0	20	99	13	123	16

*Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

9. Galley and turbid wastes are collected by gravity drains (separate from each other and the sanitary vacuum lines) which lead to one or more influent surge tank(s) for batch transfer to the treatment system feed tank. The total volume of the surge tank(s), including additional volume equal to 20% of the liquid as safety margin, is given in Table 70. The volumes were calculated as half the daytime flow figuring that 80% of the turbid water and all of the galley water is collected during the day. Each flow-through treatment system will

have its own surge tank pump, whether the number of tanks is equal to or less than the number of systems. The pump(s) should be located with the tank(s) but they need not be located near or on the same level as the treatment systems.

10. Located within the bounds of the Grumman system framework are the original 30-gallon feed tank, metering feed pump, basket centrifuge, centrate tank, centrate pump, ozone generator, ozone reactor, effluent tank and effluent pump. The sludge holding tank must be located near the ozone reactor but need not be within the Grumman system framework. It could be located on a deck below, provided the foam and centrifuge sludge can drain into it by gravity.

11. A design option for the sewage holding tank and the sludge holding tank is to have both functions accommodated in a combined holding tank. Storage and off loading for both tanks are normally done at the same time. The combined function tank is 84% larger than the sewage holding tank. Compressed air flow would also be increased by 84%. If these functions remain separate, the sludge holding tank will be provided with a gravity drained or pumped connection to the sewage holding tank for use during off loading.

12. During the system operation, the effluent pump periodically discharges a nominal 7 gpm at 20 psig from the 10-gallon effluent tank. The effluent is piped to a riser leading to the overboard discharge manifold. Where multiple WMS's are involved, they discharge to a common riser.

13. Physical cha.acteristics of the main structure and peripheral components are given in Table 71. Resource requirements are given in Table 72. Pipe sizes of interconnecting lines between separately installed components are given in Table 73.

Table 71

WMS COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight (lbs)		Volume	Dimensions (inches)		
	Dry	Filled	(cu ft)	Height	Length	Width
Commode	80	81	3.5	19	21	15
M/T Pump	125	127	1.0	10	25	7
Surge Tank Pumps	144	147	2.5	16	30	9
Main Structure	-	3056	236	85	63	76

Table 72

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Ambient Air SCFM	Cooling Water gpm
M/T Pump	1-1/2		440	3	60		
Surge Tank Pump	1/2		440	3	60		
Basket Centrifuge	2		208	3	60		
Scoop Motor		115	120	1	60		
Ozone Generator		2100	120/208	3	60	2	1
Effluent Pump	1/3		115	1	60		
Centrate Pump	1/8		115	1	60		1/4
Controls		est 200	120	1	60		

Table 73

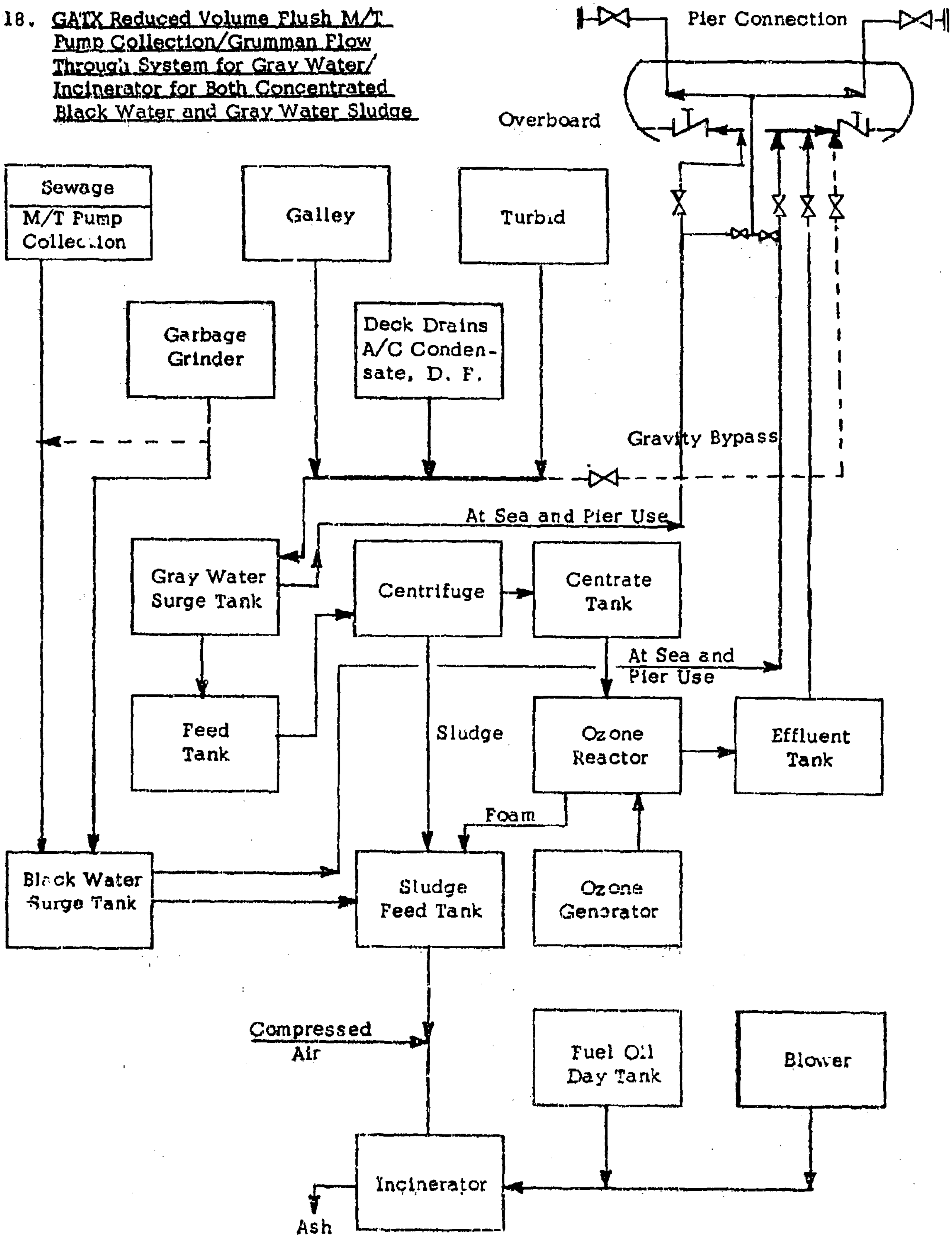
INTERCONNECTING PIPE SIZES

From	To	Size (Inches)	
Commode	M/T Pump	3	IPS
M/T Pump	Black Water Surge Tank	1-1/4	IPS
Sources	Gray Water Surge Tank	Existing	
Surge Tank Pumps	Centrifuge/Sludge Feed Tank	1/2	IPS
Effluent Pump	Riser	3/4-1	IPS

14. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. In order to simplify riser piping and overboard pumping operations, all wastes being collected or previously collected are pumped from the sewage holding tank (or the optional combined holding tank). For use in off loading, the G/T influent surge tank is provided with a gravity drained or pumped transfer line to the sewage holding tank.

15. The sewage holding tank (or combined holding tank) will have a discharge pump plus a backup pump installed. Since present pier connections accept a maximum of 30 gpm, all discharge pumps are limited to this capacity. Minimum pump flow is 10 gpm, based upon a linear velocity of 1.5 fps up to a minimum sized pipe riser of 1-1/2 inches. Discharge pump flow rates are given in Table 69. The discharge pumps should be capable of producing a positive pressure at the pier connection while pumping at the specified flow.

18. GATX Reduced Volume Flush M/T Pump Collection/Grumman Flow Through System for Gray Water/ Incinerator for Both Concentrated Black Water and Gray Water Sludge



1. This system provides flow through treatment of gray wastewater with incineration of sanitary wastes, ground garbage slurry and gray water sludge. The system is a modification of the Grumman WMS, developed for the Coast Guard, tested on the CGC Red Beech, and described in the Grumman Operation and Maintenance Instructions. In addition to internal changes in the treatment system, the method of collecting sanitary wastes is different. The point of insertion of black water into the system is also changed. The major components deleted are: the influent screen, disk centrifuge and the Grumman incinerator. The major components added are: an influent surge tank, surge tank pump and a Thiokol incinerator subsystem. The incinerator subsystem is comprised of: an incinerator, sludge feed tank, sludge pump, high pressure blower, fuel oil day tank and pump.

2. Collection of sanitary wastes is accomplished by means of small diameter pressure sewers. Pressure is provided by macerator/transfer (M/T) pumps. Since pressure sewers operate full, routing need not be sloped nor continuously descending. Gray water is collected by standard, gravity drained lines.

3. Reduced flush commodes minimize the sanitary sewage volume which is subsequently incinerated. Flushing medium will be fresh water instead of sea water. Existing commodes are replaced by GATX shock mounted, single flush-pedal units with cable actuation of the flushometer valves. They occupy approximately the same volume as standard units. The urinals are standard. Both fixtures drain by gravity into the suction line of an M/T pump mounted below the deck. An M/T pump can accommodate up to three commodes and the urinals commonly associated with them. The suction line to the pump should be short (up to eight feet to the farthest commode).

4. The commode flush mechanism incorporates a switch which actuates the M/T pump for each flush. If the piping arrangement will not

permit urinal wastewater to drain through the pump while it is not operating, then a counting mechanism will actuate the M/T pump after a nominal number (five) of urinal flushes.

5. The black water surge tank is sized to hold half a day's waste plus an additional 20% as a safety margin. Table 74 shows the volumes designated for each vessel. Slurry from the garbage grinder either drains by gravity to the surge tank or it is transferred by a solids handling pump through the pressurized sewer lines. The choice is a function of relative locations of the garbage grinder and the surge tank. A solids handling pump transfers the waste on demand to the incinerator sludge feed tank.

6. The flow through system which receives gray water for complete treatment is designed for a steady influent rate of one gpm. Only one size (or capacity) system is currently available. Table 74 presents the number of systems required for each vessel, the number of incinerators required, the hours of operation of each system and each incinerator, black water and gray water flow and the total volumes of black and gray water surge tanks.

Table 74

SYSTEM OPERATION AND VOLUMES OF SURGE TANKS

Vessel		Manning	Longest Holding Time Required (Hrs)	Gray Water Flow gpd	No. Of Systems	System Operation hr/day (Each)	Black Water Flow gpd	Incin. Feed gpd	Incinerator No.	Incinerator Ave Operation hr/day	Gray Water Surge Tank Gal	Gray Water Surge Tank Cu Ft	Black Water Surge Tank Gal	Black Water Surge Tank Cu Ft
Gallatin	(378')	182	95.5	4560	4	19.0	518	833	8	18.6	2336	312	308	41
Vigorous	(210')	60	172.0	1800	2	15.0	203	353	3	19.0	922	123	122	16
Firbush	(180')	50	277.9	1500	1	24.0*	269	294	3	16.3	768	103	101	13.5
White Sage	(133')	21	65.5	630	1	10.5	71	123	1	20.6	323	43	43	5.7
Pamlico (under constr.)	(160')	13	501.0**	390	1	6.5	44	76	1	12.7	200	27	26	3.5
Point Herron	(82')	8	99.0	240	1	4.0	27	47	1	7.8	123	16	16	2.2

* Required 4% increase in flow rate.

** Based on data from USCGC's Clamp and Shadbush with 10% additional for anticipated longer holding time requirements.

7. Galley and turbid wastes are collected by gravity drains (separate from each other and the sanitary vacuum lines) which lead to one or more influent surge tank(s) for batch transfer to the treatment system feed tank. The total volume of the surge tank(s), including additional volume equal to 20% of the liquid as safety margin, is given in Table 74. The volumes were calculated as half the daytime flow figuring that 80% of the turbid water and all of the galley water is collected during the day.

8. Each flow-through system and each incinerator feed tank will have dedicated surge tank transfer pumps for all vessels except the Gallatin. For example, on the Vigorous two pumps are used to deliver gray water to the two flow through systems and three pumps to deliver black water to the three incinerators. On the Gallatin, the gray and black water surge tanks will each have redundant pumps with diverting valves to feed the treatment systems and incinerators, respectively. All black water will be sent to the independent incinerators leaving gray water sludge for the built-in incinerators. The independent incinerators will operate 21.4 hr/day and the built-in units only 15.8 hr/day on the Gallatin. The pumps should be located with the surge tank but they need not be located near or on the same level as the treatment systems or incinerators.

9. Located within the bounds of the Grumman system framework are the original 30-gallon feed tank, metering feed pump, basket centrifuge, centrate tank, centrate pump, ozone generator, ozone reactor effluent tank and effluent pump. New equipment, entirely within the framework, are the sludge feed tank, sludge pump and incinerator blower. The incinerator is mostly within the confines of the Grumman structure and the shelf presently holding the disk centrifuge. The burner projects beyond the shelf. The incinerator control panel is mounted externally to the framework. A preliminary Thiokol arrangement sketch shows the location of the new incineration equipment modifying the Grumman design.

10. A Thiokol flow diagram of the incineration subsystem depicts the relationship of the added components. This diagram is modified by a revised sludge flow schematic, substituting continuous sludge recirculation for bubble aeration in the sludge feed tank. The drawings give interconnecting line sizes. Thiokol drawing 7U45700 gives the cross section of an IR & D Incinerator with a bill of materials. It is modified by the subsitution of a high pressure Hauck burner as shown on the Outline Drawing of the Sludge Incinerator. Drawing 7U47822 gives dimensions and details of the Sludge Tank Assembly.

11. The flow through system effluent pump periodically discharges a nominal 7 gpm at 20 psig from the 10-gallon effluent tank. The effluent is piped to a riser leading to the overboard discharge manifold. Where multiple systems are involved, they all discharge to one common riser.

12. Physical characteristics of the modified Grumman main structure and other components are presented in Table 75. Resource requirements are given in Table 76 and pipe connections or sizes are given in Table 77.

13. While the vessel is in unrestricted waters, all liquid wastes may be discharged overboard. The system is bypassed by pumping from the black and gray surge tanks. Because of the disparate sizes and the small volume of some black water surge tanks, each surge tank will have a riser to the overboard manifold.

14. Each surge tank will have a discharge pump with the tank's transfer pump serving as a backup. Since present pier connections accept a maximum of 30gpm, all discharge pumps are limited to this capacity. Minimum flow for gray water discharge pumps is 10 gpm based on a linear velocity of 1.5 fps up a minimum sized pipe riser of 1 1/2 inches. Nominal pump out time should be one hour if the resulting flow rate falls between these limits. Since the black water has passed through a macerator, smaller pumps and smaller risers will be acceptable for black water surge tank off loading. Nominal pump out time should range from 30 to 60 minutes.

Table 75

WMS COMPONENT PHYSICAL CHARACTERISTICS

Component	Weight (lbs)		Volume	Dimensions (inches)		
	Dry	Filled	(cu ft)	Height	Length	Width
Commode	80	81	3.5	19	21	10
M/T Pump	125	127	1.0	10	25	7
Surge Tank Pumps	144	147	2.5	16	30	9
Main Structure		4,380	236.0	86	63*	76**
Incinerator	800	-	23.8	40	49	21
Blower	260	-	11.0	24	36	22
Sludge Tank	50	220	6.5	31	30	12
Control Box	125	-	3.5	30	20	10
Fuel Oil Day Tank						
Gallatin		Δ1778	38.1			
Vigorous		Δ 702	15.0			
Firebush		Δ 585	12.5			
White Sage		Δ 246	5.3			
Pamlico		Δ 152	3.3			
Point Herron		Δ 94	2.0			

* Plus 10 inches for control panel, 20 in. W x 30 H

** Plus projection of incinerator nozzle.

Δ Weight of oil

Table 76

WMS COMPONENT RESOURCE REQUIREMENTS

Component	HP	Watts	Volts	Phase	Hertz	Amp.	Ambient Air SCFM	Compressed Air SCFM	Fuel Oil gph	Cooling Water gpm
M/T Pump	1-1/2		440	3	60					
Surge Tank Pump	1/2		440	3	60					
Basket Centrifuge	2		208	3	60					
Scoop Motor		115	120	1	60					
Ozone Generator		2100	120/208	3	60		2			1
Effluent Pump	1/3		115	1	60					
Centrate Pump	1/8		115	1	60					1/4
Incinerator			208	3	60		100	12	1-1/2	
		Opt.	460	3	60					
Blower	2		208	3	60					
		Opt.	460	3	60					
Fuel Oil Pump	est.1/4		120	3	60					
Sludge Pump	1/4		120		60					
Controls (GAC)		est.200	120	1	60					
Controls (Thiokol)		est.200	120	1	60					

Table 77

INTERCONNECTING PIPE SIZES

From	To	Size (inches)	
Commode	M/T Pump	3	IPS
M/T Pump	Black Water Surge Tank	1 1/4	IPS
Sources	Gray Water Surge Tank	Existing	
Surge Tank Pumps	Centrifuge/Sludge Feed Tank	1/2	IPS
Fuel Oil Pump	Incinerator	1/4	IPS
Effluent Pump	Riser	3/4-1	IPS
Incinerator	Atmosphere	7 1/2 ID x 14 OD* Insulated Stack	

*Stack may vary in size depending upon installation.

* U.S.G.P.O. 727-101/1302-1696